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January 2012

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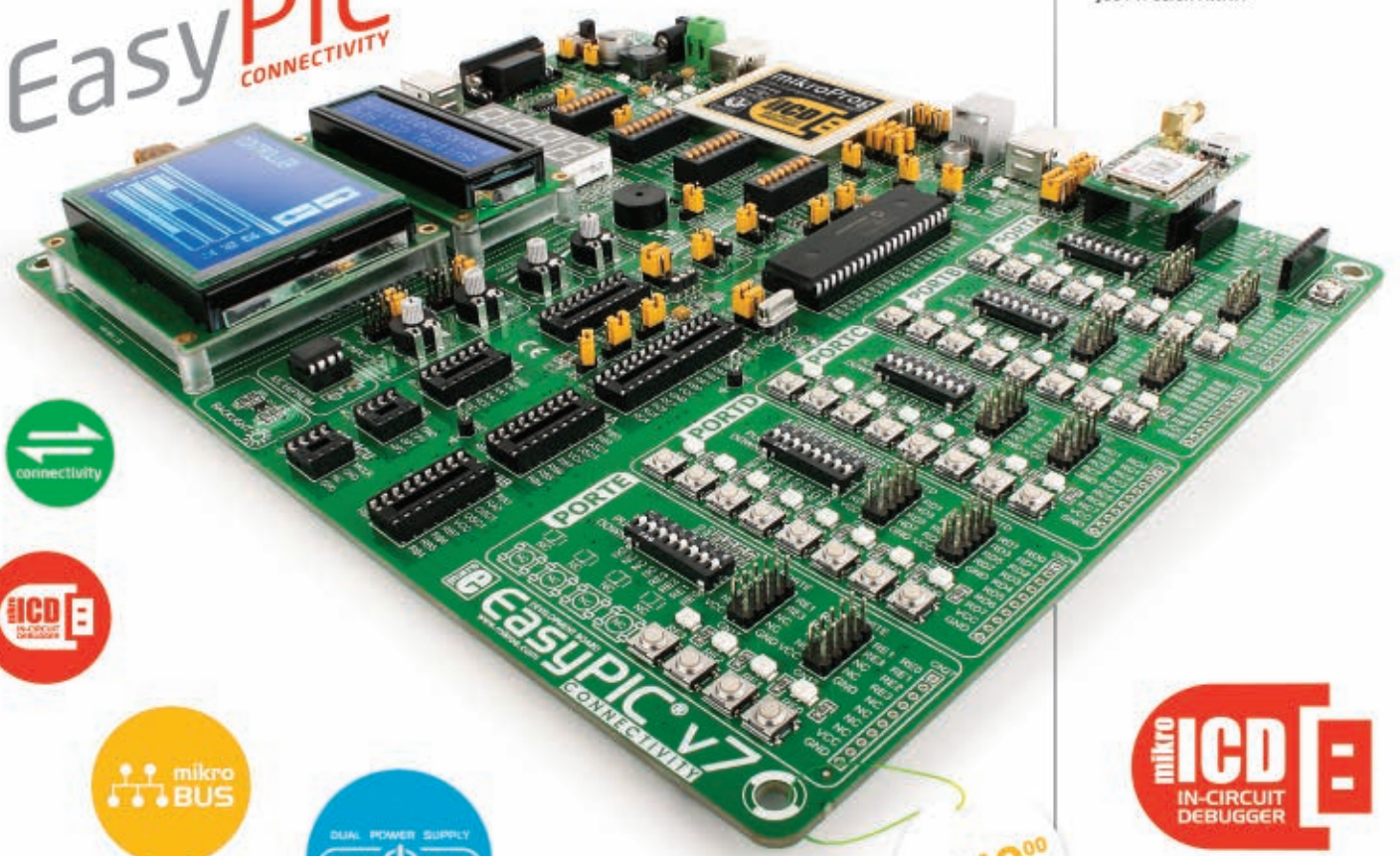

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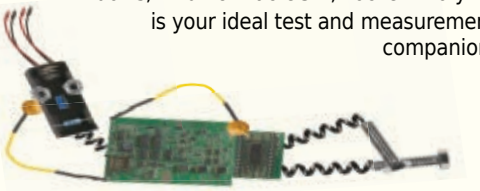
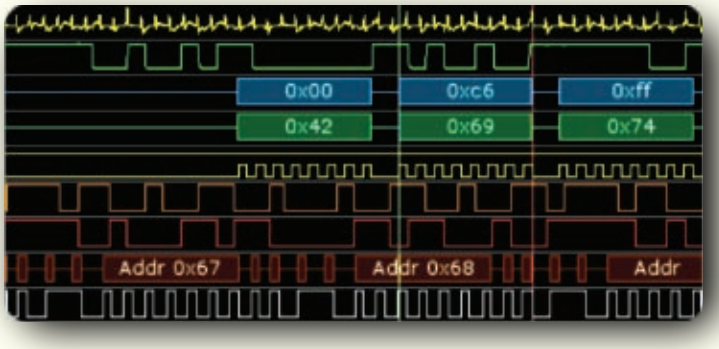


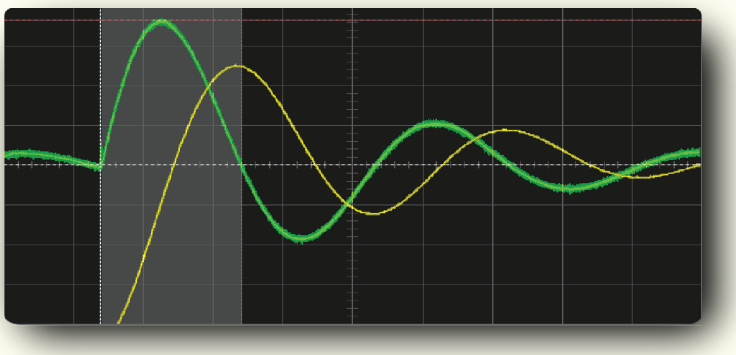
New Model

Pocket Analyzer

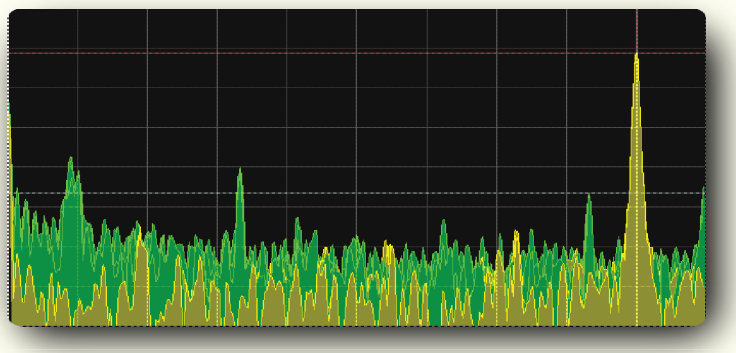
Protocol Analyzer



Digital Oscilloscope



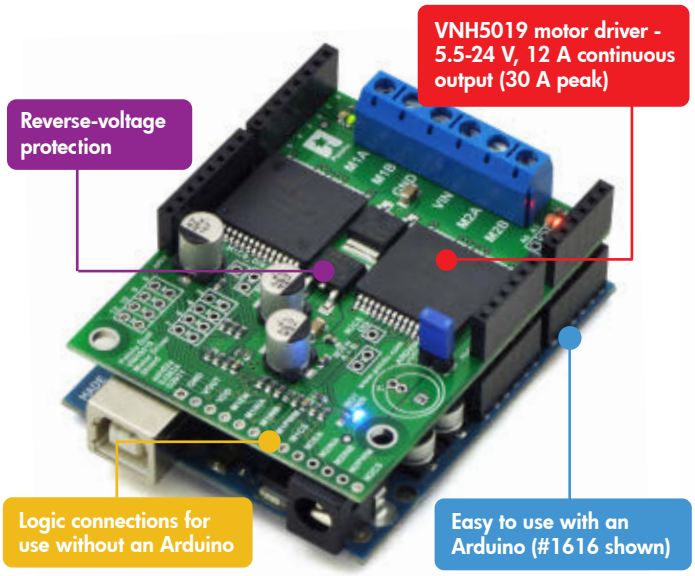
Spectrum Analyzer



bitscope.com/nv

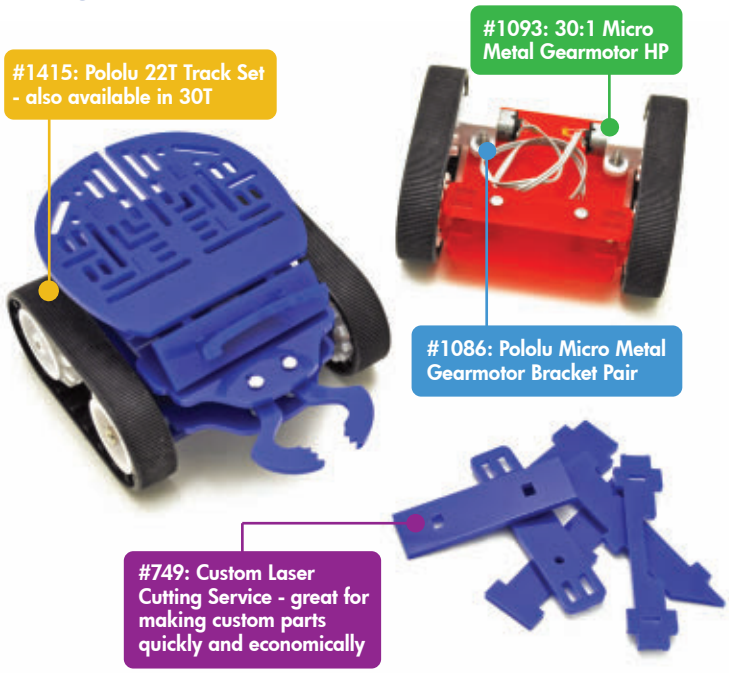
Motor Drivers:

Item #2502: Dual VNH5019 Motor Driver Shield for Arduino


VNH5019 motor driver - 5.5-24 V, 12 A continuous output (30 A peak)
Reverse-voltage protection
Logic connections for use without an Arduino
Easy to use with an Arduino (#1616 shown)

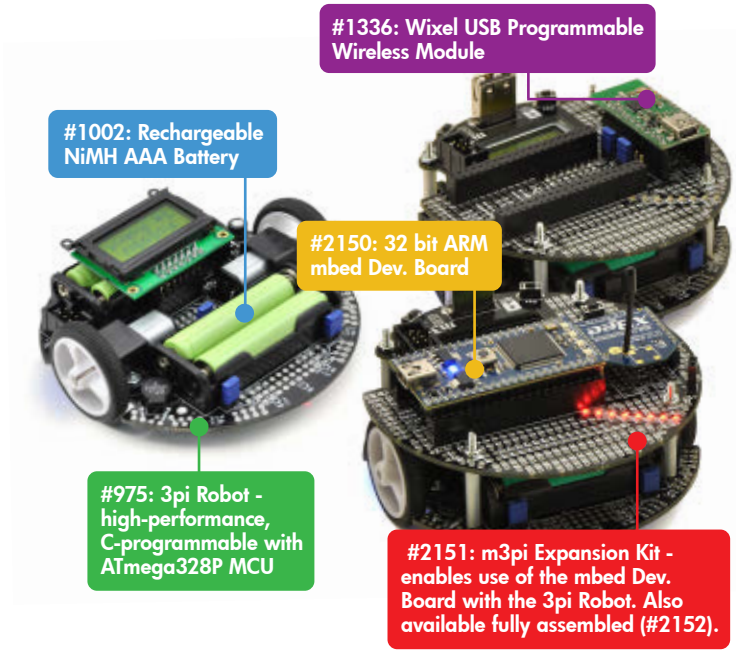
Custom Laser Cutting:

Design Your Own Chassis


#1415: Pololu 22T Track Set - also available in 30T
#1093: 30:1 Micro Metal Gearmotor HP
#1086: Pololu Micro Metal Gearmotor Bracket Pair
#749: Custom Laser Cutting Service - great for making custom parts quickly and economically

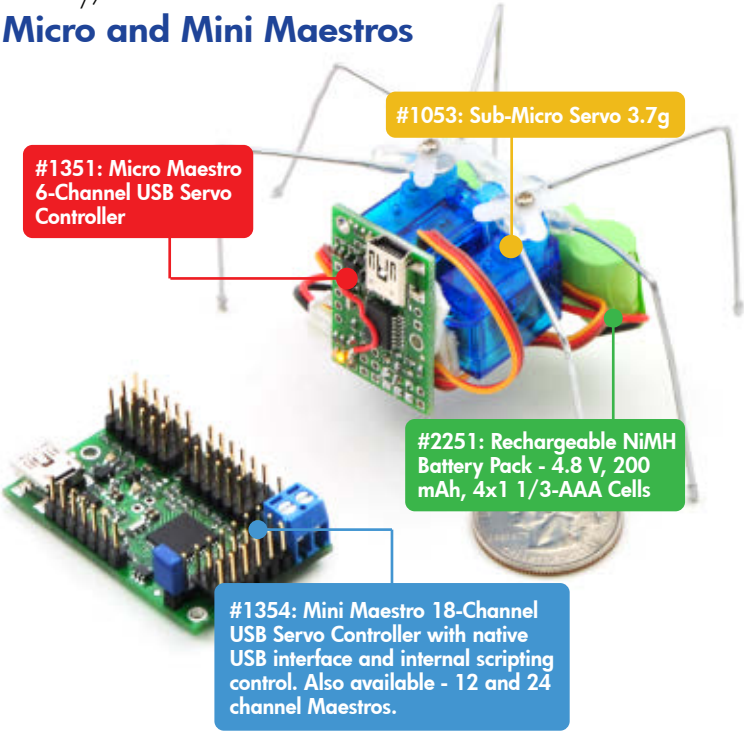
Robots and Robot Kits:

Pololu 3pi and m3pi


#1336: Wixel USB Programmable Wireless Module
#1002: Rechargeable NiMH AAA Battery
#2150: 32 bit ARM mbed Dev. Board
#975: 3pi Robot - high-performance, C-programmable with ATmega328P MCU
#2151: m3pi Expansion Kit - enables use of the mbed Dev. Board with the 3pi Robot. Also available fully assembled (#2152).

Hobby/RC Servo Controllers:

Micro and Mini Maestros


#1053: Sub-Micro Servo 3.7g
#1351: Micro Maestro 6-Channel USB Servo Controller
#2251: Rechargeable NiMH Battery Pack - 4.8 V, 200 mAh, 4x1 1/3-AAA Cells
#1354: Mini Maestro 18-Channel USB Servo Controller with native USB interface and internal scripting control. Also available - 12 and 24 channel Maestros.

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January 2012
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Projects & Features

28 Build a Stereo Gain Controller
Tired of being blasted off your seat by excessive audio volume when you switch television channels or when the commercials come on? To mitigate such unnerving changes in program audio, a popular automatic volume controller from the vacuum tube era was updated to today's technology. This circuit is also useful in home recording.
■ By Dev Gualtieri

34 Build the Garage Door Closer
Leave your garage door open?
No problem! This handy device will close it automatically for you. (Plus, you don't even have to remember to replace batteries in this unit.)
■ By Brian Beard

38 Build a USB Volume and Mute Controller for Your PC
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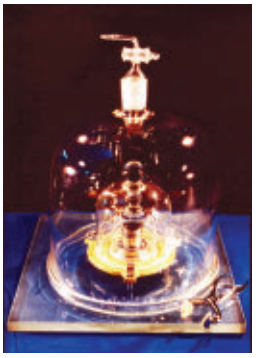

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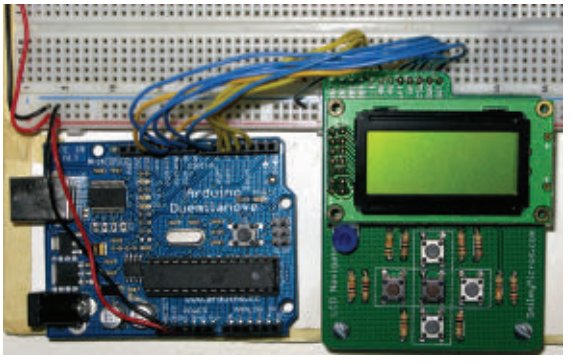

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GSPA TSOP-48S
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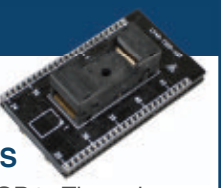
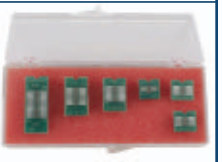


GSPA PLCC-44
44-Pin PLCC to Through - Hole Prototyping Adapter

GSPA-K1
5-pin DIN connector housed on a PC board



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DEVELOPING PERSPECTIVES

How Old is Old Enough?

One of the most often asked questions in my inbox is 'how old is old enough to begin working with electronics?' The answer, of course, is that it depends on the individual, what you mean by 'working with,' and the amount of supervision provided by an experienced or at least alert adult.

I began disassembling radios and electric toys as soon as I could handle a screwdriver. When I was 11, I built a ham radio transmitter with parts recycled from a discarded TV — working alone in my father's workshop.

Today, allowing an unsupervised 11 year old to disassemble a potentially lethal high voltage circuit probably constitutes child abuse in some states. Fortunately, the CRT has been supplanted by the lower voltage LCD display and modern electronics, in general, operate at relatively harmless voltages.

If you're looking to introduce electronics to an eight or nine year old, I'm a big fan of the Snap Circuits series which is sort of like LEGOs with embedded components. The entry-level model is around $30 from Amazon. With color-coded LEGO-like components, you and your youngster can build over a hundred different circuits — from a water alarm to a timer.

The problem with the series is that the user manual is written for someone who can read at a high-school level. So, the kit is great for pre-teens, as long as someone who can read the manual and explain the circuits supervises them.

Although the Snap Circuit and similar products can be used by teens, the solderless electronic breadboard approach is more fitting for capable hands. It takes a good deal of dexterity to plug in ICs without bending the leads. A breadboard and battery or simple power supply and a handful of components are not only inexpensive, but relatively limitless in terms of circuit possibilities.

However, unlike the Snap Circuit, it's easy to cross connections and burn out components — that is, unless there's someone watching over the builder's shoulders. There's also something to be said for the experience of burning up a few inexpensive components — the lesson can carry over to more expensive circuits later.

If you're a regular reader of this column, you know that I'm a big fan of teardowns, especially when they're supervised. Nothing can beat a knowledgeable person tearing down a smoke alarm, compact fluorescent bulb, or other device with a step-by-step description of components and circuit theory. One of my early mentors used to walk me through a teardown and then hand me the tools and let me reassemble everything. I'd often end up with a few extra screws here and there, but the lessons stuck.

The real challenge today is making the introduction to electronics memorable and exciting. After all, electronics as a hobby has evolved considerably since the days when computers were fabricated with discrete components. For example, if your project culminates in a blinking LED, it's probably not going to compete well with your smart phone or tablet.

I've had good success using robotics as a vehicle for circuit design and testing. It's no Angry Birds app, but a walking robot — regardless of how simple — is bound to capture the interest of youngsters of any age. **NV**

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TECH KNOWLEDGEY 2012

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

TRACTOR BEAMS BECOMING A REALITY?

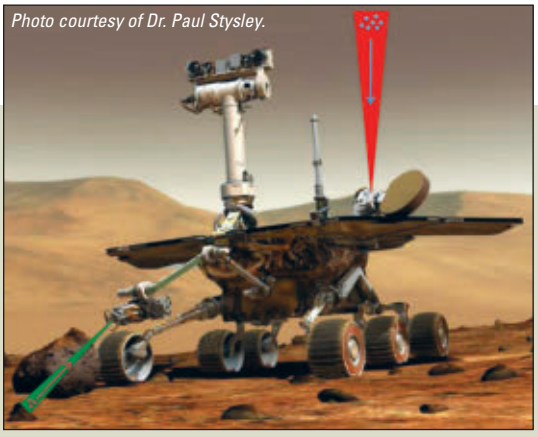


Photo courtesy of Dr. Paul Stysley.

■ Concept image of a Mars rover equipped with a tractor beam device.

No, we're not talking about the headlights on a John Deere. As anyone who has ever watched Star Trek knows, any decent starship will be fitted with a device — known as a tractor beam — that produces a gravity-like attraction field capable of dragging in pretty much any object, regardless of its mass and inertia. Although the concept appears seriously impractical for any type of large objects, it has been known for some time that certain types of lasers can move small, solid items. For example, last year, scientists at the Australian National University moved some tiny particles 1.5 m through the air using a Laguerre-Gaussian beam. Now, NASA's Office of the Chief Technologist is getting into the act and has awarded $100,000 to a group of laser experts at the Goddard Space Flight Center (**www.nasa.gov/centers/goddard**/) to study three different approaches for creating the laser equivalent of a DustBuster®.

The first technique involves the "optical tweezers" concept in which two counterpropagating light beams generate a ring-like geometry that traps particles in the dark core of the overlapping beams. Varying one of the beams' intensities heats the air around the trapped particle and thereby moves it along the center of the ring. The drawback here is that the system requires an atmosphere, which isn't exactly omnipresent in space.

The second employs "optical solenoid beams" which were introduced in a 2010 issue of *Optics Express* and described as "diffractionless solutions of the Helmholtz equation whose diffraction-limited in-plane intensity peak spirals around the optical axis, and whose wavefronts carry an independent helical pitch." Here, the particles are drawn back along the entire light beam, and no atmosphere is required.

The remaining technique has never been demonstrated, but it involves the use of a Bessel beam in which rings of light surround a central point. In theory, the beam could induce electric and magnetic fields in an object's path and use the spray of forward-scattered light to pull it backward, against the beam itself. Whichever method — if any — proves practical, it is expected to be useful not only for extraterrestrial particulate matter but also for single molecules, viruses, RNA, and even functioning cells on Earth. ▲

COMPUTERS AND NETWORKING

NEW ULTRABOOK UNDER $1,000

The Ultrabook category of computing has been defined by Intel as basically a notebook computer that fills the gap between tablets and lightweight laptops — sort of like a netbook with everything upgraded. They are configured with low voltage, high powered processors, fast power-up, extended battery life, and fast storage, typically in the form of SSDs. Late last year, Acer introduced its first Ultrabook: the Aspire S3 series. Going with the trend toward lean and mean, it's only 0.51 to 0.68 in thick and weighs in at just under 3 lb. The operating system is stored in a 20 GB SSD, allowing it to resume from sleep mode in as little as 2 sec. A battery charge is said to last up to 50 days if unused, and you get about 6 hr of continuous computing time. Other features include a second-generation Core i5 processor, a 320 GB hard drive, and 4 GB of memory. The S3-951 includes Dolby® Home Theater v4. The display is a 13.3 in HD backlit LED with 1366 by 788 maximum resolution. Prices start at $899. For details, visit **us.acer.com**. ▲

■ The Acer Aspire S3 Ultrabook™ starts at $899.

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

COMPUTERS AND NETWORKING CONTINUED

ANOTHER WEARABLE COMPUTER

■ NEC's TeleScouter wearable computer features a head-mounted display.

Every now and then, someone gets the bright idea of producing a wearable computer, hoping that it will be commercially successful. So far, hope has never triumphed, but it appears to be NEC's turn to take another whack at it. What could make a difference here is that the NEC TeleScouter is designed for industrial settings where its price tag (reported at about $5,200 for the unit plus a hefty $25,000 for the software) may not be prohibitive. Plus, the company is aiming to sell only 1,000 systems in the next three years. Perhaps the machine's most interesting feature is the head-mounted AIRScouter display which projects images into the wearer's eyes. It incorporates clear glasses that allow the operator to view the real world at the same time. The system can also be provided with camera-equipped glasses, microphones, and earphones, making it more flexible for remote field operations.The unit is also Bluetooth enabled. The innards include an ARM 500 MHz processor and 256 MB of memory running Windows Embedded CE 6.0. The system weighs about 430 g (15 oz) and will operate better than 4 hr on a charge. At present, the machine appears to be available only in Japan, but NEC's issuance of an English-language press release would indicate that TeleScouter will eventually find its way to our shores. ▲

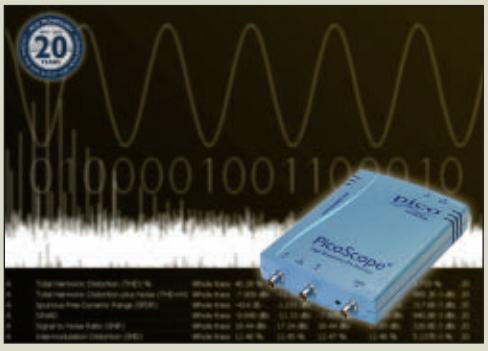
■ Turn your iPad into a laptop with Belkin's Keyboard Folio.

UPGRADE YOUR IPAD 2 WITH A KEYBOARD CASE

One of the nice things about an iPad is that it eliminates the bulky keyboard. However, one of the drawbacks to the iPad — if you do any amount of real typing — is that it eliminates the bulky keypad. Hence, meet the Keyboard Folio product from the folks at Belkin (**www.belkin.com**). What you get is an integrated Bluetooth keyboard and protective folio case designed specifically for the iPad 2. It features TruType™ keys that are designed to offer a computer-style typing experience, as opposed to flimsy rubber keyboards. The tri-fold design hides the keys and protects the screen when the unit is not in use. You can pick one up for an MSRP of $99.99. ▲

CIRCUITS AND DEVICES

NEW 2-CHANNEL, 16-BIT PC OSCILLOSCOPE



■ The PicoScope 4262 is a full-featured PC-based 'scope that doubles as a spectrum analyzer.

There's nothing wrong with a standard benchtop 'scope, but if you already have a Windows-based PC at hand, you might want to hook it up to one of Pico Technology's units and save some space. The newest is the PicoScope 4262 which is a two-channel, 16-bit very high resolution oscilloscope (VHRO) with a built-in low distortion signal generator. With a 5 MHz bandwidth, it can be used to analyze audio, ultrasonic, and vibration signals; characterize noise in switched mode power supplies; measure distortion; and perform a range of precision measurement tasks. It includes a function generator and arbitrary waveform generator that has a sweep function to enable frequency response analysis. According to the company, it also offers mask limit testing, math and reference channels, advanced triggering, serial decoding, automatic measurements, and color persistence display. It also provides a menu of 11 automatic frequency-domain measurements in spectrum analyzer mode. You can get further details at **www.picotech.com** and compare the 4262 to other models in the lineup. This one has a street price of a little more than $1,100, including two probes and a carrying case. ▲

CIRCUITS AND DEVICES CONTINUED

■The Lytro light field camera allows continuously variable focus on the same image — even after taking the photo.

TAKE 4-D PHOTOS

Once in a while, something comes along that is actually new and amazing, and it appears that Lytro (**www.lytro.com**) has come up with one. It seems that Lytro CEO Ren Ng wrote an award winning Ph.D. thesis on light field theory back in 2006 while at Stanford University. He then founded a company to move his research from theory to product, and the result is the Lytro light field camera. Like your garden variety Canon or Nikon, it is a digital still camera. However, a light field camera — also known as a plenoptic camera — uses an array of microlenses to capture all the rays of light in a scene; in this case, 11 million rays. It uses "a light field sensor that collects the color, intensity, and the direction of every light ray flowing into the camera, capturing a scene in four dimensions." As a result, one can focus and refocus the image even after shooting the photo. If you share an image online, Lytro's "light field engine" travels with it so that the picture remains interactive on such devices as browsers, tablets, and mobile phones.

Other features include an 8x optical zoom lens with a constant f /2 aperture, instant turn-on and an instant shutter (with no need for autofocus; there is no shutter delay), high sensitivity for use in low light situations without a flash, and storage of 350 or 750 images, respectively, with the 8 GB or 16 GB models. Because all Lytro photos inherently include 3-D data, the company will be releasing software later this year that will allow 3-D viewing and scene perspective shifting. Lytro offers a free software download that enables users to import pictures from camera to computer and share them via Facebook, blogs, email attachments, and so forth. At this moment, it is Mac OS only, but a Windows version may be available by the time you read this. You can pick one up for $399 or $499, depending on the memory capacity. For an onscreen demonstration, visit **www.lytro.com/living-pictures**. ▲

INDUSTRY AND THE PROFESSION

BING LOSING BIG

If the headline above makes you think more of "White Christmas" than search engines, you're not alone. Nobody else is using Microsoft's **www.bing.com**, either. Reportedly, Microsoft has lost about $5.5 billion (you read that right) since launching the service in 2009 and continues to sink cash into it at a quarterly rate of almost $1 billion. It doesn't appear to be a major concern, though, as the company has some $53 billion in cash on hand and even boosted its quarterly dividend last year — up to $0.20 per share. Well, it's only money. ▲

REDEFINING BASIC MEASUREMENT UNITS

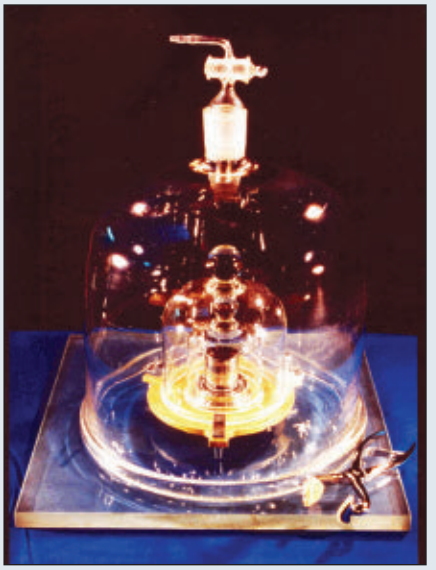
Last November, the International General Conference on Weights and Measures (CGPM) approved a plan to redefine four of the seven base units of the International System of Units (SI), which seems to be creating a frenzy (or at least a lack of a universal yawn) in the field of metrology. The units in question are the kilogram, the ampere, the kelvin, and the mole, all of which "will be redefined in terms of invariants of nature; the new definitions will be based on fixed numerical values of the Planck constant, the elementary charge, the Boltzmann constant, and the Avogadro constant, respectively."

There isn't much here to interfere with your sleep patterns, however. For one thing, the changes won't take place until a range of technical requirements for agreement and some unspecified uncertainties are met, and the CGPM won't even meet again until 2014. For another, the changes will be so infinitesimal that almost no one will

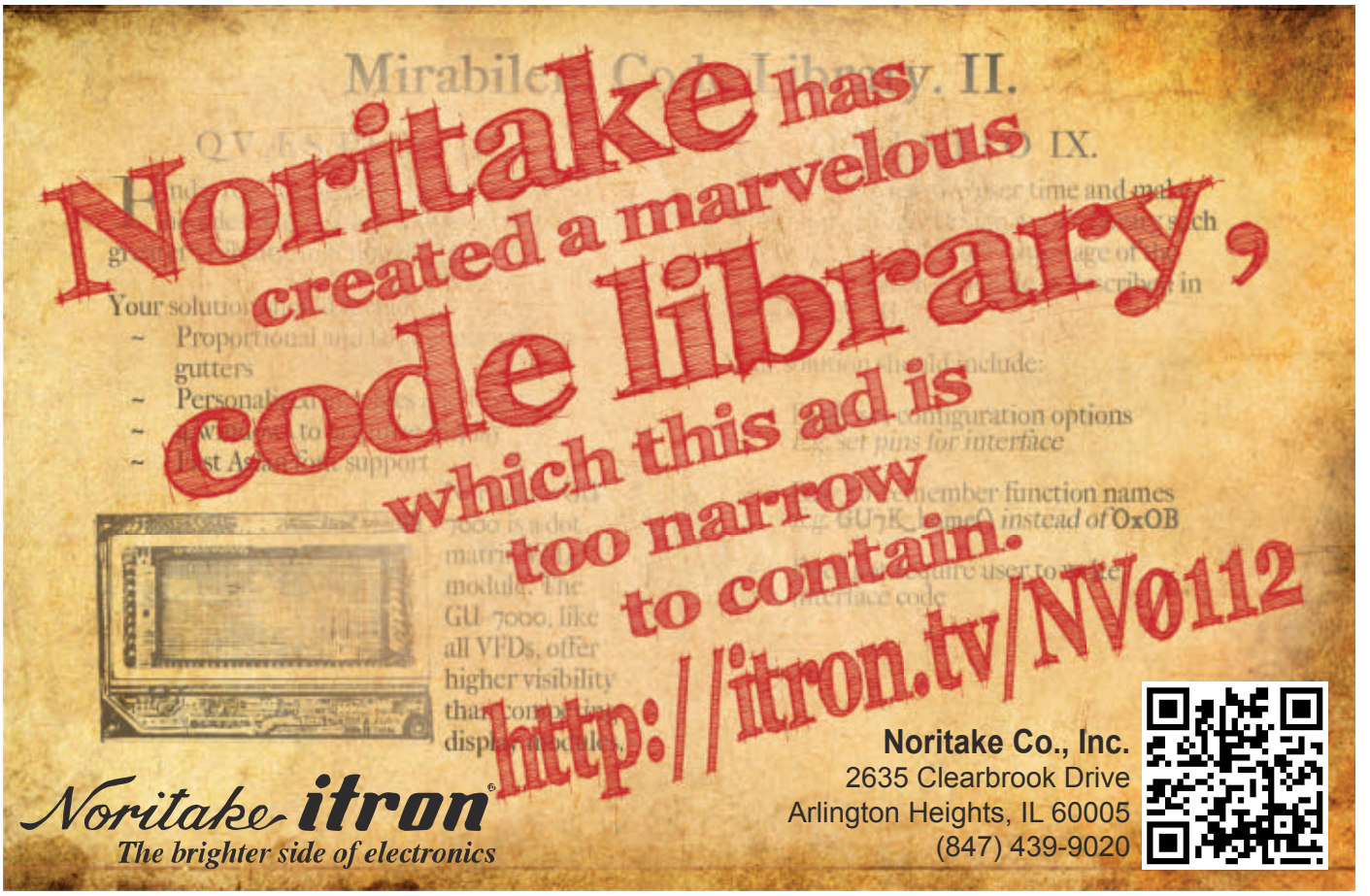
continued ...

INDUSTRY AND THE PROFESSION CONTINUED

notice the difference. The definition of a kilogram, for example, will change by only a few parts in 100,000,000, so a kilo of bananas will cost pretty much the same. But we thought you'd like to know. Updates will be available at the National Institute of Standards and Technology (NIST) website (**www.nist.gov**). **NV**



■ Say goodbye to the international prototype kilogram — a platinum-iridium object stored in an arrangement of three nested bell jars.


Noritake has created a marvelous code library, which this ad is too narrow to contain.
http://itron.tv/NV0112
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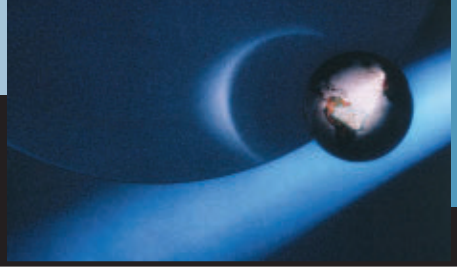


■ BY L. PAUL VERHAGE

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

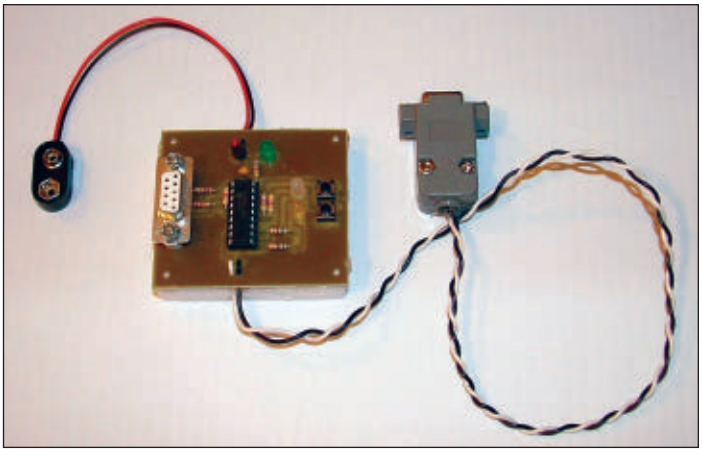
GLOBAL POSITIONING SYSTEM SIMULATOR, VERSION 2.0

As some readers may recall, I wrote about a simple GPS simulator back in July '09. That version used a PICAXE-08M and transmitted only the $GPGGA sentence. It was a fine simulator for near space flight computers that only monitored this single GPS sentence. However, it wasn't satisfactory for a GPS tracking system monitoring additional GPS sentences. Preventing the expansion of the GPS simulator was the limited memory of the PICAXE-08M. I can now report on a new and improved version of the GPS simulator that expands the original simulator into one suitable for testing most GPS tracking systems.

There are four significant improvements in this new version of the GPS simulator. First, it displays the altitude on a PC while producing its GPS output for the tracker under test. This lets you monitor the progress of the balloon flight in real time. Second, five additional GPS sentences are included in the output. The output includes the $GPGGA, $GPGGL, $GPGSA, $GPGSV, $GPRMC, and $GPVTG sentences. The only one not included is the $GPZDA sentence (in order to keep the output updating properly at once per second). However, if one is willing to forgo the simultaneous reporting of the balloon's flight on a PC, then the simulator can also reproduce this last remaining sentence.

Third, not only does the new version of the simulator produce output like a GPS, it also replicates a GPS attaining and losing its position lock. A pushbutton switch toggles the lock status of the simulator (between lock and no-lock, and back again) and a bi-color LED indicates the current lock status. The fourth and final improvement permits the simulation of a neutrally buoyant weather balloon. A tap on the second pushbutton switch launches the balloon simulation and software controls the ascent, buoyancy, burst, descent, and landing of the balloon.

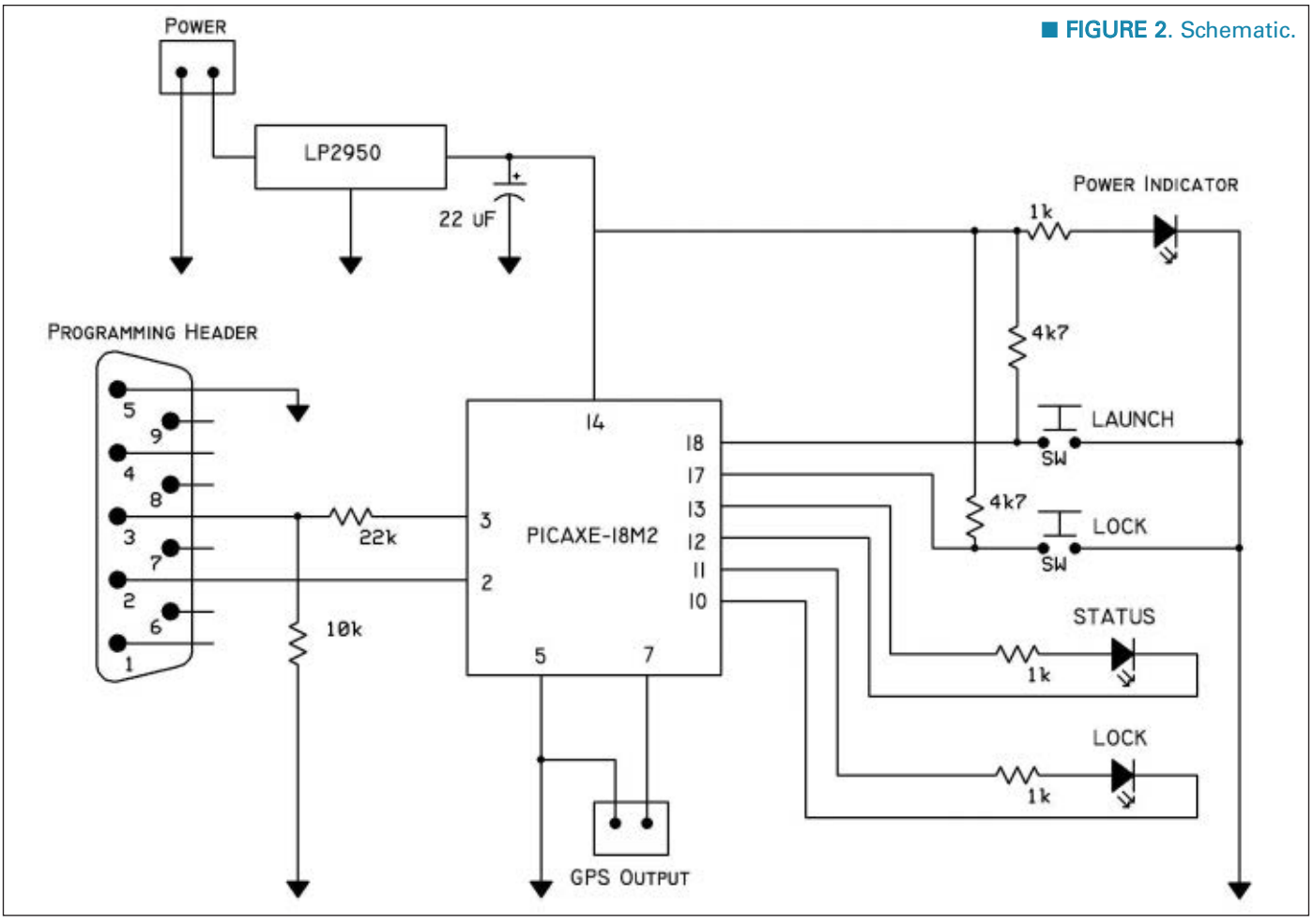
■ **FIGURE 1.** GPS Simulator, version 2.



A second bi-color LED displays the balloon's flight status (on the ground, rising, floating, descending, or landed). All these features fit inside of 1,617 bytes of the PICAXE-18M2 memory so there's room to grow the simulation. The simulator runs off a nine volt battery and terminates in a female DB-9 connector that directly plugs into any GPS tracker's serial GPS port.

The simulator's electrical design is pretty simple because software does most of the simulation work. The LP2950 is a low drop-out voltage regulator and permits the circuit to continue operating down to about 5.3 volts (a pretty dead nine volt battery). The voltage regulator uses the 22 µF electrolytic capacitor to reduce voltage ripples. You can replace this capacitor with a larger value capacitor if that's what you have handy. The resistors act as either pull-ups or current limiters.

The pushbutton switches signal the GPS simulator when to toggle the position lock and when to launch the balloon. At startup, the GPS simulator has no lock and the balloon is on the ground. The Lock LED is red to indicate no position lock and the GPS output is set to a string of sentence headers and zeros. Once the Lock button is pressed, the simulator begins producing a valid series of



■ **FIGURE 2.** Schematic.

GPS sentences once every second and the Lock LED turns green. If the GPS lock is switched off after the balloon is already in flight, the simulator keeps track of its virtual position while the GPS simulator reports no position lock.

The balloon is virtually launched by pressing the Launch button. Until then, the GPS position doesn't change and the Status LED is off. The Status LED is green during ascent, toggles between red and green during float, is red during descent, and is off on the ground. The simulator's programming port is a female DB-9 soldered to the PCB, and it does double duty by sending position reports to a PC. The GPS output is through a second female DB-9 attached to the end of a two-wire cable. Attaching it to a cable makes it easier to plug the GPS simulator into a GPS tracker.

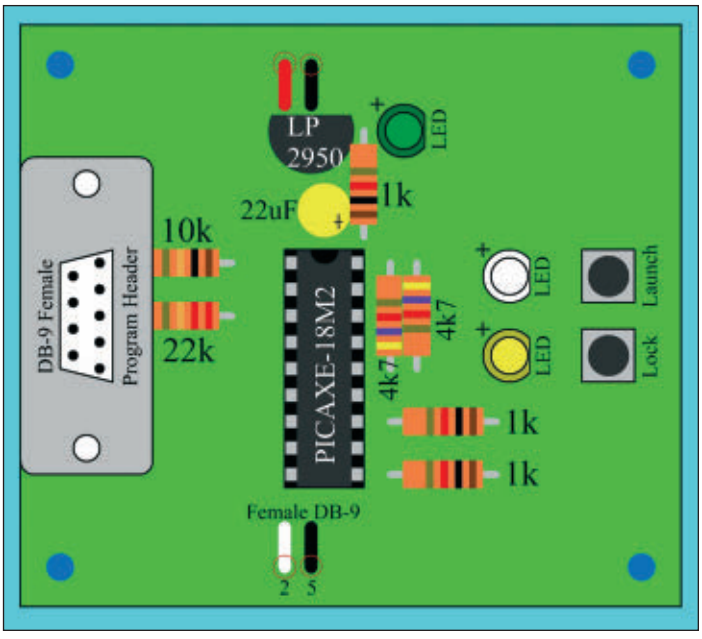
MAKING THE GPS SIMULATOR VERSION 2.0

The **Parts List** shows the components needed to make the GPS simulator, version 2.0. Many of them you'll already find in your parts bin.

All holes in the PCB (printed circuit board) are 0.032", except for the four holes used for strain relief. These holes (circled in **Figure 3**) are drilled larger at around 0.050" in diameter. After drilling the PCB, begin by soldering the resistors. Follow with the capacitor and then the IC socket. Do not insert the PICAXE-18M2 at this point. Next, solder the LP2950 voltage regulator and the two miniature momentary pushbutton switches. The Lock and Launch LEDs are bi-color LEDs, and the LED near the voltage regulator is a standard single color LED. Solder all nine of the female DB-9 connector pins to the PCB. Afterwards,

Parts List

- 18-pin DIP socket, 300 mils wide
- PICAXE-18M2
- 4K7, 1/4W resistor (2)
- 1K, 1/4W resistor (3)
- 22K, 1/4W resistor
- 10K, 1/4W resistor
- 22 µF electrolytic capacitor, 100 mil lead spacing
- LP2950 five-volt low drop-out voltage regulator
- LED
- Bi-color T1¾ LED (2)
- Tactile normally-off pushbutton switch (2)
- Nine volt battery snap
- DB-9 female connector, PCB pins
- DB-9 female, solder cups
- DB-9 hood kit
- 4-40 bolts, 1/2" long (2)
- 4-40 nylocks (2)
- 4-40 plastic or aluminum spacers, 0.2" long (2)
- Wire, 24 AWG, two feet long
- PCB (use the pattern included in the article downloads)



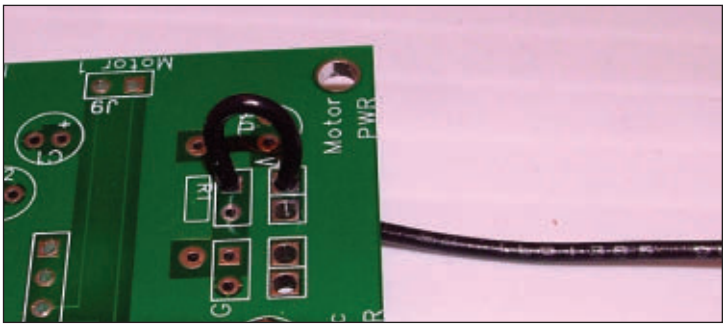
■ **FIGURE 3.** Solder the components to the PCB as indicated in this placement diagram.

place the spacers between the wings of the DB-9 and the PCB, and bolt the DB-9 to the PCB with the 4-40 hardware. When soldering the electrolytic capacitor, voltage regulator, and LEDs, watch their polarities.

All that remains to solder are the wires for the battery snap and the GPS cable. The battery snap solders to the two solder pads at the top of the PCB diagram in **Figure 3**. The diagram shows the battery snap leads in red and black to match those in the battery snap. The other two wires (one black and one white) for the GPS cable appear at the bottom of the placement diagram. The other ends of these wires terminate in pins 2 and 5 of the DB-9 connector with the solder cups.

The wires in the battery snap and the GPS cable are strain relieved to the PCB so they will not break off from everyday use. Solder the nine volt battery snap first. Strip 1/4" of insulation from the ends of the wires (if they are not already stripped) and pass them through the large diameter strain-relief holes. Then, bend them over and insert the bare ends into their correct solder pads as shown in **Figure 4**.

I find leaving a small loop in the wires helps press the bare ends into the solder pad. After soldering both leads of the battery snap, trim the wires and pull the wires tight.



There is no need for a loop after soldering since the large diameter hole in the PCB blocks most of the strain on the battery snap from reaching the soldered connection. Now, repeat this for the two wires of the GPS cable. These wires are about a foot long and have 1/4" of insulation stripped from both ends. Start by soldering one end of each wire to the PCB with the same method used for the battery snap. The other end of each wire solders to a solder cup in the DB-9. In **Figure 4**, placement diagram above, each wire is labeled with its correct solder cup — 2 and 5. Now, the GPS simulator is ready for its first test.

TESTING THE GPS SIMULATOR

The first test locates any electrical shorts in power. Use a DDM set for continuity and check between the positive and negative terminals in the battery snap. The meter **should not** ring. If it does, check the underside of the PCB for any solder shorting traces. Next, test that the proper voltage appears on the PCB. Set the DMM for voltage and plug a nine volt battery into the snap. Measure between pins 5 and 14 on the IC socket and verify that relative to pin 5, there is positive five volts (give or take 1/2 volt) on pin 14. Remove the battery snap and install the PICAXE-18M2. The last test is a test of communications. Start up the PICAXE Editor and set it for the PICAXE-18M2. Type the following program into the editor:

```
PAUSE 1000
DEBUG
```

Plug the nine volt battery back into the battery snap and download this program. Verify that the editor programmed the PICAXE and that the Debug window has one update. At this point, you're ready to download the GPS simulator code, which you'll find at the article link. After downloading this code into the PICAXE, start up the terminal program in the editor by clicking the F8 key. Note that the Lock LED is red (no position lock) and the Launch LED is off (balloon on the ground). Unplug the programming cable from the DB-9 on the GPS simulator PCB and plug it into the DB-9 on the end of the GPS cable. The PICAXE terminal will now show data as in **Figure 5**.

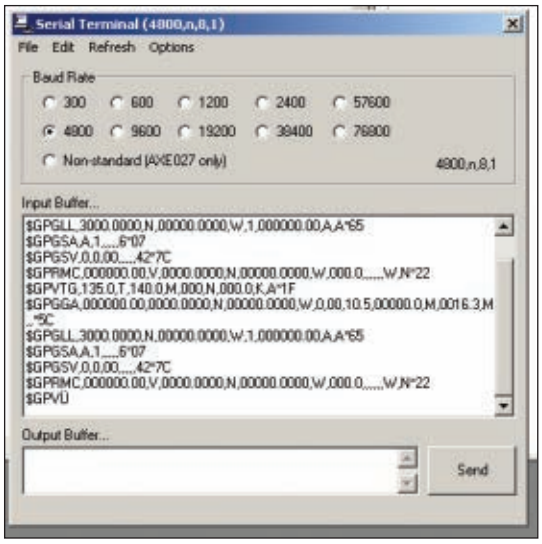
If every test has been successful, then complete the last step in the construction of the GPS simulator. Squirt hot glue around the solder cups in the DB-9 of the GPS cable. Then, fill one half of the plastic DB-9 hood with hot glue and lay the female DB-9 into the hood. Top off any low spots with hot glue and then fill the other plastic DB-9 hood with hot glue. Close the second hood and bolt the entire assembly together. Finish by back-filling the DB-9 hood with additional hot glue. When back-filling the DB-9 hood, squirt glue into the opening in the back of the hood until the hot glue is about to run out.

■ **FIGURE 4.** This image shows the insulated wire passing through the larger strain relief hole on the right. It then bends over, and the stripped end of the wire passes through the smaller solder hole to be soldered.

Now, let the glue cool.

SOFTWARE SETTINGS

The GPS simulator code runs a series of five nested loops to create the GPS time. The nested loops update the hour, minute, second, position, altitude, and wind speed. The code updates and sends position reports once per second. The parameters used to define the flight profile are located at the beginning of the code, so you won't have to go digging around for them. The parameters are as follows.



■ **FIGURE 5.** Before there is a GPS position lock, the GPS sentences look like this.

StartHour: The starting hour of the simulation in UTC (any value from 00 to 23).
Day: The day of the month in the simulation (any value from 1 to 31).
Month: The month in the simulation, in two digits (any value from 01 to 12).
Year: The last two digits of the year in the simulation (any value from 00 to 99).
LaunchAltitude: The elevation of the launch site in meters (any realistic value).
AscentRate: The ascent rate of the balloon in feet per minute (any value from 300 to 1,200).
FloatAltitude: The altitude float is to occur (any value lower than burst altitude).
BurstAltitude: The altitude balloon burst is to occur (any value higher than LaunchAltitude).
DescentRate: The descent rate of the parachute in feet per minute at sea level (any realistic value around 1,000).
RecoveryAltitude: The elevation of the recovery site in meters (any value less than BurstAltitude).

The important thing to notice is that if the burst altitude is lower than the float altitude, the balloon will never become neutrally buoyant in the simulation.

USING THE GPS SIMULATOR

Disconnect the battery and plug the GPS cable into the GPS port of the tracker under test. Then, power-up both the GPS tracker and the GPS simulator. The GPS simulator immediately begins producing output like a GPS without a position lock.

When you push the Lock button, the GPS begins reporting a stationary position and the Lock LED turns green. There is some built-in jitter into the reports, so the reported position jumps around slightly like a real GPS. Once you push the Launch button, the balloon begins rising at the ascent rate set in the software. The Status LED is green indicating the balloon is ascending. Again, there's a small jitter in the position reports just like a real GPS.

The balloon continues to rise at a constant rate until it reaches 40,000 feet. At this point, the ascent rate drops to 80% like a real balloon (the actual altitude this occurs at is variable, however, 40,000 feet is a good value). The balloon continues to rise until it reaches float or burst altitude. At float, the Status LED flashes alternately red and green. At burst, the Status LED turns red indicating descent.

The descent continues until the simulator altitude descends below the recovery elevation. The Status LED turns off and the GPS reports a fixed position with some jitter. The flight path and heading remain fixed; there is no accounting for changing wind directions in the simulation. However, the wind speed does change and there's a mild jet stream at 40,000 feet.

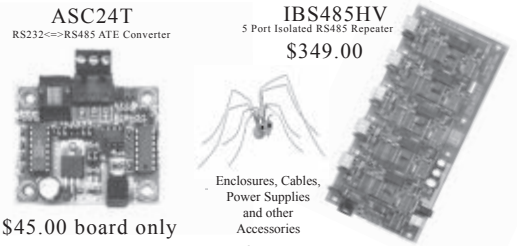
A PC plugged into the simulator's programming and running the PICAXE terminal program will display the current altitude of the simulation. There's still room in memory for upgrades to the simulator. However, if you make significant changes, you may need to change the speed of the PICAXE or shorten the code to keep position reports appearing once per second. I plan to experiment with software upgrades to permit the testing of cutdown devices and of GPS-based amateur rocket altimeters. I'll soon make a kit available on my website (**NearSys.com/catalog**) for anyone who doesn't want to go through the trouble of making the PCB or locating parts.

Onwards and Upwards,
Your near space guide **NV**

Neutrally Buoyant

The neutrally buoyant condition occurs when the lift of the balloon is too close to the weight of its payload. Initially, the balloon slowly rises, perhaps on the order of 300 feet per minute. However, at some point during the ascent, the balloon's lift is too weak compared to the balloon skin's tension against expansion. At that point, the balloon stops rising and it just drifts downwind. Eventually, the batteries in the GPS tracker discharge and die. In enough time, solar ultraviolet will degrade the latex in the balloon and pop the balloon. However, by then, the balloon could be hundreds of miles away. The chances are now poor that you will ever recover the payload. To guard against this, always fill the balloon with enough gas to lift two or three pounds more than the payload weight. Otherwise, adding a cutdown device to the balloon load line is in order. After activation of the cutdown, the payload separates from the balloon and begins its descent. Without the weight of the payload, the balloon shoots rapidly upward in altitude and bursts. The GPS simulator version 2.0 described here permits you to test the operation of a cutdown device while it remains on the ground.

RS485/422/232/TTL



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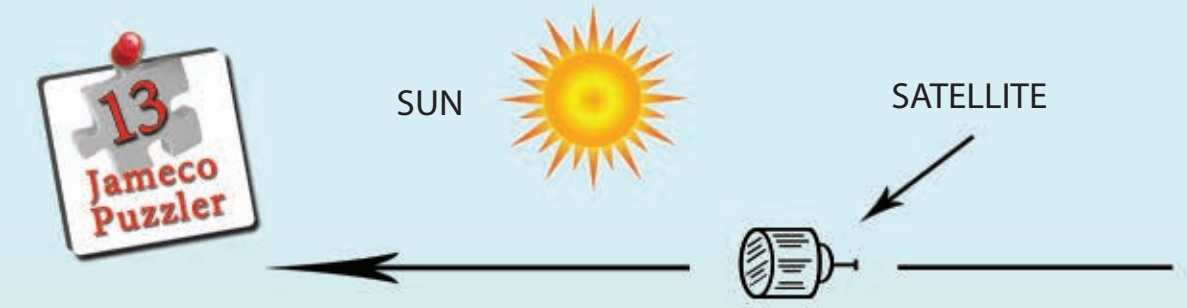

VOLCANO

SATELLITE: "AEROSOL CLOUD IS GONE"

JOE NOVICE: "AEROSOL CLOUD STILL THERE"

Can you describe any of the three methods Joe used to detect the aerosol?

Satellites provide global coverage of clouds, water vapor, dust, smoke and the ozone layer. The colorful images provided by the data from these satellites looks very impressive. But satellite instruments don't always stay calibrated and problems can occur when satellite orbits drift. Amateur scientist, Joe Novice learned about this when he heard a satellite scientist say that the global aerosol cloud formed by the eruption of a giant volcano had dissipated much sooner than expected. Joe suspected the satellite was simply wrong, but he was not a satellite scientist. How did he use some everyday items and several electronic components to prove he was right?

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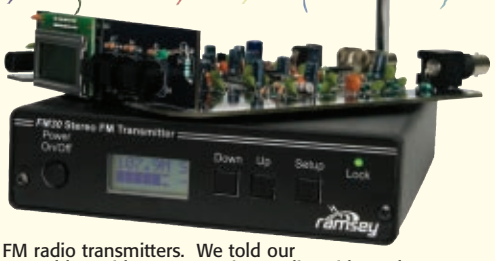


For nearly a decade we've been the leader in hobbyist FM radio transmitters. We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!

The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version with 1W output for our export only market!

All settings can be changed without taking the cover off! Enter the setup mode from the front panel and step through the menu to make all of your adjustments. A two line LCD display shows you all the settings! In addition to the LCD display, a front panel LED indicates PLL lock so you know you are transmitting. Besides frequency selection, front panel control and display gives you 256 steps of audio volume (left and right combined) as well as RF output power.

A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use!

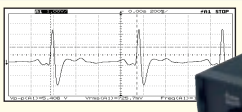
The design includes EMI filters on line level audio and power inputs and a state of the art microstrip PCB inductor to reduce microphonics for the ultimate in alignment free operation. RF output is brought out to a professional, well shielded rear panel BNC connector for a perfect antenna match. Standard RCA connectors are used for left and right line level audio inputs. Both the FM30B and FM35BWT operate on 13.8 to 16VDC and include a 15VDC plug in power supply.

(Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)

FM30B	**Digital FM Stereo Transmitter Kit, 0-25mW, Black**	**$199.95**
FM35BWT	**Digital FM Stereo Transmitter, Assembled, 0-1W, Black (Export ONLY)**	**$299.95**

Electrocardiogram ECG Heart Monitor

- ✔ **Visible and audible display of your heart rhythm!**
- ✔ **Bright LED "Beat" indicator for easy viewing!**
- ✔ **Re-usable hospital grade sensors included!**
- ✔ **Monitor output for professional scope display**
- ✔ **Simple and safe 9V battery operation**



Use the ECG1C to astound your physician with your knowledge of ECG/EKG systems. Enjoy learning about the inner workings of the heart while, at the same time, covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The documentation with the ECG1C covers everything from the circuit description of the kit to the circuit description of the heart! Multiple "beat" indicators include a bright front panel LED that flashes with the actions of the heart along with an adjustable level audio speaker output that supports both mono and stereo hook-ups. In addition, a monitor output is provided to connect to any standard oscilloscope to view the traditional style ECG/EKG waveforms just like you see on ER... or in the ER! 10 hospital grade re-usable probe patches are included together with the matching custom case set shown. Safe 9V battery operation.

ECG1C	**Electrocardiogram Heart Monitor Kit With Case & Patches**	**$44.95**
ECG1WT	**Electrocardiogram Heart Monitor, Factory Assembled & Tested**	**$89.95**
ECGP10	**Electrocardiogram Re-Usable Probe Patches, 10-Pack**	**$7.95**

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.

MK171 **Voice Changer Kit** **$14.95**

Steam Engine & Whistle

Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.

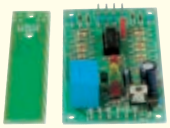
MK134 **Steam Engine & Whistle Kit** **$11.95**

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1 **Laser Trip Sensor Alarm Kit** **$29.95**

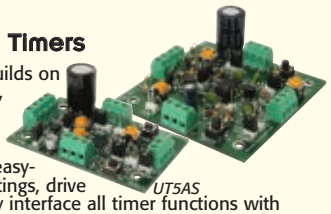
Liquid Level Controller



Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.

K2639 **Liquid Level Controller Kit** **$21.95**

Ultimate 555 Timers



UT5AS

This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

UT5A	**Through Hole 555 Timer/Osc Kit**	**$24.95**
UT5AS	**SMT 555 Timer/Osc Kit**	**$26.95**

USB PIC Programmer

Finally, a compact USB PIC Programmer with a 20 pin ZIF socket for easy programming of most Microchip PIC Flash devices that does not require low voltage programming. Plus it uses USB therefore no more RS232 compatibility blues!

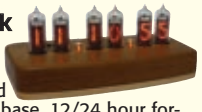
CK1301 **USB PIC Programmer Kit** **$34.95**

Doppler Direction Finder

Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.

DDF1 **Doppler Direction Finder Kit** **$169.95**

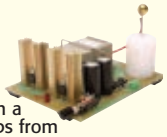
Retro Nixie Tube Clock



Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Tube kits also available.

IN14TM **Teak Maple Nixie Clock Kit** **$329.95**

HV Plasma Generator



Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

PG13 **HV Plasma Generator Kit** **$64.95**

Speedy Speed Radar Gun

Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.

SG7 **Speed Radar Gun Kit** **$69.95**

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

PR2 **Broadband RF Preamp** **$69.95**

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U **3-In1 Multifunction Solder Lab** **$134.95**

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Four-Mode Vehicular Keyless Entry Test Set

Ahh!!... the conveniences of today's technology in our modern world! Voice recognition, LED's instead of incandescent bulbs, on-board computers, on-board hard drives, automatic parallel parking, automatic radar cruise control, and of course, wireless remote controls! They make it so simple, just have the "key" (called a key fob) somewhere in your pocket or purse, get near the vehicle, it knows that you are there! Touch the door handle and the vehicle unlocks. Get in and touch the start button and the vehicle starts. You have yet to use a key through the whole process! And don't forget all the wireless controls for your house lights, building access and entertainment systems. They're so great… until they don't work!

Testing your system is easy. To test the complete key fob-to-vehicle and vehicle-to-key fob communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20KHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. The modulated IR signal is detected and will illuminate the IR test LED on the test set. If you know a few "secrets" you can also see if the tire pressure sensors/transmitters are generating signals or the built-in garage door opener in your rear view mirror is transmitting a signal! But the WCT3's uses go beyond the automotive world. The majority of building wireless access systems also utilize 125 kHz. Just hold the test set near the building access sensor and the WCT3 will detect the 125 kHz signal. That will help you troubleshoot door access locations that are not working. It gets even better... you can use the WCT3 to test virtually any other 315 MHz, 433 MHz, 125kHz, 20kHz and IR wireless control system to verify generation of a signal. The WCT3 test set is housed in a compact 2.25" x 4.6" x 9" case and is powered by a standard 9VDC battery (not included).

WCT3 Four Mode Keyless Entry Test Set Kit $59.95

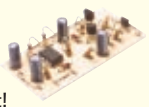
Passive Aircraft Monitor

PATENTED!

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 Passive Aircraft Receiver Kit $89.95

Voice Activated Switch



Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.

VS1 Voice Switch Kit $9.95

OBDII *CarChip Pro*

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 CarChip Pro OBDII Monitor-Asmb $79.00

RF Preamplifier

The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

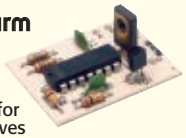
SA7 RF Preamp Kit $19.95

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 Touch Switch Kit $9.95

Mad Blaster Warble Alarm



If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

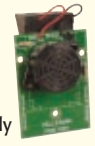
MB1 Mad Blaster Warble Alarm Kit $9.95

Laser Light Show

Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

LLS1 Laser Light Show Kit $49.95

Water Sensor Alarm



This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

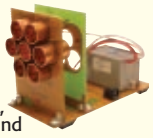
MK108 Water Sensor Alarm Kit $6.95

USB DMX Interface

Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.

K8062 USB DMX Interface Controller Kit $67.95

Air Blasting Ion Generator



Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 Ion Generator Kit $64.95

Tickle-Stick Shocker

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 Tickle Stick Kit $9.95

Tri-Field Meter Kit

THE GHOST DETECTOR!

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C Tri-Field Meter Kit $74.95

Electronic Watch Dog

A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike my Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

K2655 Electronic Watch Dog Kit $39.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

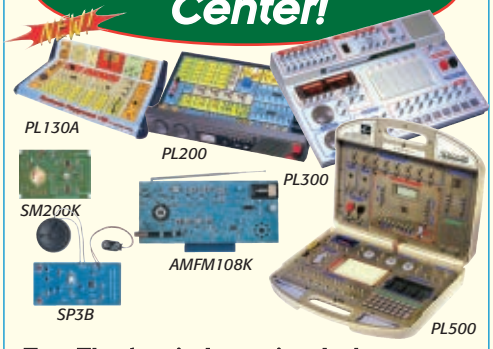
MC1 Mini Electret Condenser Mic Kit $3.95

Sniff-It RF Detector Probe

Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

RF1 Sniff-It RF Detector Probe Kit $27.95

The Learning Center!



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- ✔ **Super comprehensive training manuals!**

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If you are looking to either learn or hone up on your through hole or SMT soldering skills check our SP3B and SM200K Practical Soldering Labs. You will be a soldering master in no time!

We make it easy to learn IC's while at the same time, building a neat AM/FM radio with our AMFM108K AM/FM IC lab kit. You will have a blast AND learn!

PL130A	**130-In-One Lab Kit**	**$39.95**
PL200	**200-In-One Lab Kit**	**$84.95**
PL300	**300-In-One Lab Kit**	**$109.95**
PL500	**500-In-One Lab Kit**	**$249.95**
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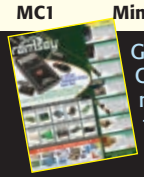
SM200K	**SMT Practical Soldering Lab**	**$22.95**
AMFM108K	**AM/FM IC Lab Kit & Course**	**$34.95**



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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ **Flickering Lamp Circuit**
- ✓ **USB Tester**
- ✓ **Replacement Inductor**

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to: Q&A@nutsvolts.com**

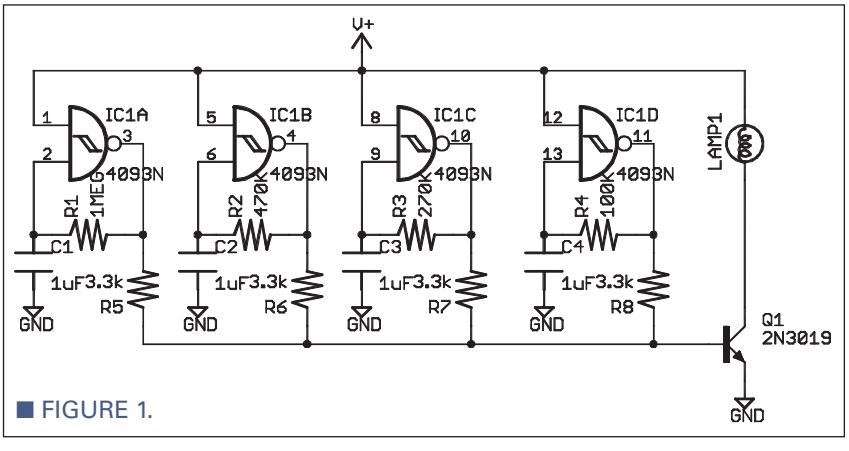
www.nutsvolts.com/index.php?/magazine/article/january2012_QA

FLICKERING LAMP CIRCUIT

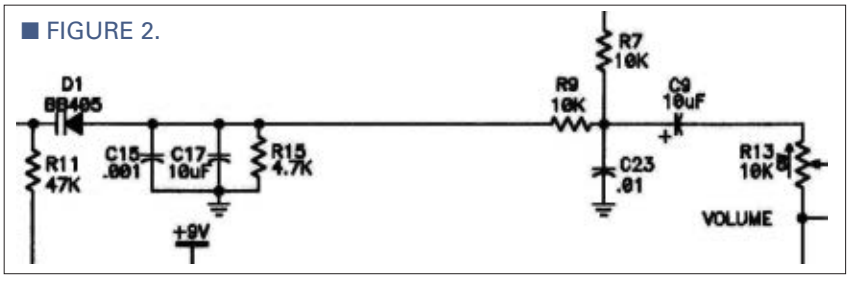
Q I use several oil lanterns that I modified and wired to use 12 volt low voltage landscape sockets and lamps running off a transformer for my Halloween display. I would like to get the bulb to flicker like a flame to be more natural. Is this possible and can I do it cheaply?

— Bill Bartsch

A In December '05, the late T.J. Byers published a neat circuit for an LED; I have modified it with a power transistor to drive a lamp (see **Figure 1**). The transistor is rated at 1/2 amps and may need a heatsink. You can tweak the values to get the effect that you like. The four oscillators are running at different frequencies and are not synchronized, so there is a variation in the light intensity. If your lamp requires more than 500 mA, a TIP41 transistor will work but you will need to tweak the resistors 5-8 for the best effect.



■ FIGURE 1.



■ FIGURE 2.

FM RADIO PROBLEM

Q I purchased and built an FM radio in kit form from one of your advertisers (**RamseyElectronics.com**) and, although it works just fine, I encounter a problem when I increase the volume. It 'skips' to the next station. Can you please point out where the problem may be? I'm using a 12 VDC @ 100 mA power adapter for it, instead of 9 VDC as indicated on the schematic that came with the kit.

— Michael Williams

A I have reproduced the suspect part of the circuit in **Figure 2**. The DC from the discriminator is fed back to the tuning diode to hold the station on frequency. If the coupling capacitor, C9, is leaking or in backwards, changing the volume will drag the DC voltage down and cause the frequency to change. Check C9 and if it is not backwards, replace it with a tantalum 10 µF, 16V. The circuit should work okay on 12 volts.

WATER SOFTENER QUESTION

Q I recently received an ad for an "electronic water softener." It appears to consist of a coil around a copper pipe with a controller attached. My questions are: Does this have a scientific basis? Wouldn't the copper pipe shield the water from magnetic and electrostatic fields? Do you know of anyone that has used one?

— Kenneth Keck

A I have never heard of electronic water softening. You are correct; the copper pipe will shield the water from AC fields. I am sure the ad did not explain how it works because it doesn't. I found out that this device is marketed by Eden Pure — the company that markets the electric heater

scam — so that cinched it for me.

LED CIRCUIT WANTED

Q I want to ask a few questions on powering red, white, and blue LEDs in parallel. I want a circuit that will power 13 red, 20 white, and 12 blue T-1 LEDs connected in parallel. I didn't use current drop resistors and they powered up nicely with six AA batteries. They are all medium brightness LEDs, but I had to hook each color up separately to its own supply (two AA batteries for each color). I was finding that when hooked up in parallel, the power took the path of least resistance and lit the red LEDs only. My question is how could I use the lightest weight battery and smallest battery possible to power all three different color LEDs with the least amount of parts, having the T-1 LEDs wired in a string of parallel 1206 or 805 surface-mount parts okay also and with one battery even a coin cell type or similar but at the same time wanting to use T-1 style LEDs and a circuit for surface mount LEDs also would be appreciated as well as a circuit for T-1 LEDs so that I have the freedom to use either type LEDs. Keeping in mind the smallest circuit board and lowest weight batteries and least amount of parts possible.

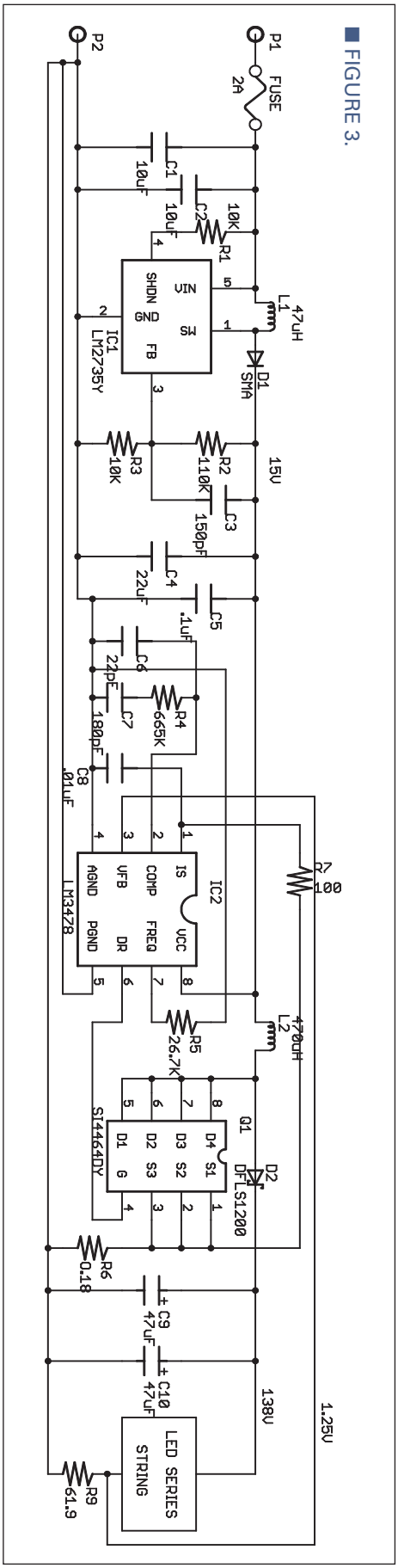
— Scott Gates

A The different color LEDs operate at different voltages. Red is the lowest at two volts, green is 2.2 volts, and blue is 3.5 volts. Since white LEDs are combinations of red, green, and blue, white LEDs operate at the highest voltage of 3.5 volts. Operating a red LED at three volts without a **series** current-limiting resistor will overheat it and it will not last long. The most efficient way to operate LEDs is in series, but you will need a boost power supply. If you run them all in series, you will need 138 VDC and the power required at 20 mA is 2.76 watts. The input power will be about three watts, and the current from two AA cells will be one amp. An alkaline cell is rated 2.5 amp-hours, so such a system will run for about two hours. A coin cell doesn't have the current capability to run this circuit. My design (**Figure 3**) uses two switching regulators because high voltage MOSFETS won't turn on with three volts. The first switcher boosts three volts to 15 VDC, then the second boosts 15V to 140 VDC. A current sense resistor (R9) provides feedback to regulate the current, not the voltage. If the load is open, the voltage will go to the max which may be more than the output capacitors can stand. I used National Semi's Web Bench to design the switchers; the LM3478 is a current mode switcher; R6 is the current sense which shuts off Q1 at the current peak. The drive voltage output of the LM3478 is 7.5 volts; so that has to be sufficient to turn on Q1. The parts are all surface-mount; see the Parts List in **Figure 4**.

NEED USB TESTER

Q I have a USB port built into the radio with Bluetooth; went to try it out and almost set my car on fire. I was charging a cell

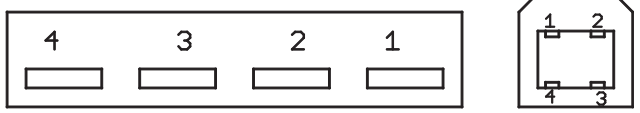
■ FIGURE 3.



■ FIGURE 4. LED DRIVER PARTS LIST

PART	DESCRIPTION	PKG	MOUSER PART #	PRICE
R6	0.18 OHM 1/10 W	0603	71-RCWL0603R180JQEA	1.45
ALL OTHER RESISTORS	1/8W 1%	0805	71-CRCW0805-VALUE-E3	0.08
C1, C2	10 µF, 16V, CERAMIC	A CASE	81-GRM31CR6K106KA88	0.64
L1	43 uH, 4.5A	P0250	673-P0250.473NLT	1.50
L2	470 uH, 0.5A	P0752	673-P0752.474NLT	0.99
D1	30V, 1A, SCHOTTKEY	SMA	652-CD214A-B130LF	0.11
D2	200V, 1A, SCHOTTKEY	PWR-DI	621-DFLS1200-F	0.74
C3	150 pF, 50V, 5%	0805	80-C0805C151J5G	0.11
C4	22 µF, 25V, 10%	1206	81-GRM31CR61E226KESL	1.93
C5	0.1 µF, 50V, 20%	1206	810-C3216X7R1H104M	0.11
C6	22 pF, 50V, 5%	0805	581-08055A220J	0.10
C7	180 pF, 50V, 5%	0805	80-C0805C181J5G	0.17
C8	.01 µF, 50V, 5%	0805	80-C0805C103J5R	0.07
C9, C10	47 µF, 200V, 20%	16MM	140-VEJ470M2DTR1616	1.65
IC1	CURENT MODE PWM	SOT23-5	926-LM2735YMF/NOPB	3.57
IC2	CURRENT MODE PWM	SO8	926-LM3478MM/NOPB	2.96
Q1	N-MOS, 200V, 1.7A	SO8	781-SI4464DY-T1-E3	2.14

■ FIGURE 5.



phone that has a USB connecter. While it was charging, I got a phone call. The radio turns off and becomes the speaker for the phone. When I was finished, I put the radio back and didn't realize that there was anything wrong with the cell phone till I smelled smoke. It was hot enough to start a fire. I had the battery replaced and it wouldn't charge. The phone started charging again after a few tries but a message came up "cable not recommended for this device." I got a new charger and the phone works like the day I bought it. I tried plugging my cell phone into the USB port and it started to heat up again. I think the USB port in the car was damaged so I went to the dealer to have it tested and they told me the only way to test the USB port is to pull the dash apart. I was wondering if there is a device I can plug into the USB port to tell me if it works properly because I really don't want to have the dash pulled apart unless I have to. I also wanted to know if there is a difference in USB cables because I was thinking that maybe it was only made to charge a cell phone and not made for data. I would like all the help you can give me on this.

— Robert Schwartz

A The USB port supplies five volts DC to power accessories and charge batteries. You can measure the voltage with a voltmeter; if it is more than 5.5 volts, it is defective. The layout of the common USB ports is shown in **Figure 5**. It makes no difference if the cable is made for data or not; #4 is ground but if the USB has five contacts, #4 is not used and #5 is ground; #1 is +5 volts. I tried my advice and found there's not enough space to probe without causing a short, so the best alternative is to cut a USB cable and measure the red and black wires. Red is plus and black is minus in all cases.

REPLACEMENT INDUCTOR

Q I am having trouble finding a replacement inductor for repairing an audio output for a TV. The TV is using a TI part #TPA3123D2 class D amplifier. My problem is that I found two bad inductors, 22 uH. I went on TI's website and found a substitute inductor: TOKO part #A7503AY-220M. The problem is that I can't purchase this part separately. I went on the Coilcraft website and found a substitute for that inductor. My question is: How important is it to use the TI recommended part? Do you have any suggestions as to where I can purchase the inductors? What parameters are important besides the inductance value, current rating, and minimum resistance? Here are the two subs I found: Coilcraft #DROI10-223L and TDK #TSL1112RA-220K2R9-PF.

A The class D amplifier operates at 250 kHz, so the self-resonant frequency of the 22 uH inductor has to be higher than that. Not a problem for any 22 uH coil, I am sure. If the amp is operating from 12 VDC, full bridge, and with an eight ohm speaker, the peak current will be at least 1.1 amps so the rating of the inductor should be higher; say two amps. The resistance should be as low as possible, certainly not over one ohm. The other criteria is that it has to fit in the space provided. For a through hole part, Mouser part number 434-07HCP-220K, 22 uH, .055 ohms, 2.3 amps, should do it. If the inductor is surface-mount, you will have to search either Mouser or Digi-Key to find a compatible form. Or, you can solder the leads of the through hole part to the surface-mount pads and use RTV to support the inductor. If the amp is operating from 24 volts, half bridge, the current will be the same and the Mouser part and the two subs that you found will work. NV

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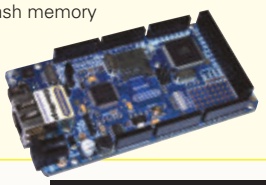
The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Power-over-Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.



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- 54 digital I/O lines
- 16 analog inputs
- MicroSD memory card slot
- Prototyping area
- Switchmode power supply

USBDroid, Arduino-compatible with USB-host support

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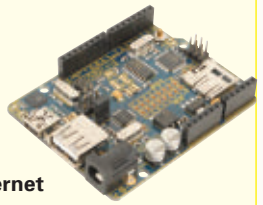
This special Arduino-compatible board supports the Android Open Accessory Development Kit, which is Google's official platform for designing Android accessories. Plugs straight into your Android device and communicates with it via USB. Includes a built-in phone charger.



- ATmega328P MCU running at 16MHz
- USB host controller chip
- Phone charging circuit built in
- 14 digital I/O lines (6 with PWM support)
- 8 analog inputs
- MicroSD memory card slot

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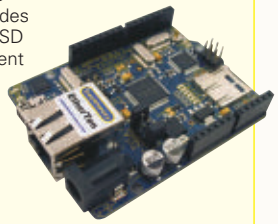
This Arduino-compatible development board includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.



- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built in
- Used as a web server, remote monitoring and control, home automation projects
- 14 digital I/O lines (6 with PWM support)
- 8 analog inputs

Getting Started with Arduino

BM-7130 $20.75 plus postage & packing

This book explains what Arduino is, how it works and what you can do with it. It also includes a project to build, complete with how to write the code to make it work.

- Softcover, 118 pages. 216 x 140mm

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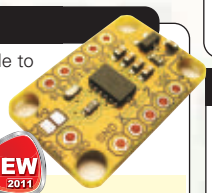
We have a huge range of simple to advanced add-ons that provide input for your Arduino projects. Visit our website for our full range and more details.



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Humidity & Temperature Sensor Module	XC-4246 $14.50

ProtoShield Basic

XC-4214 $3.25 plus postage & packing

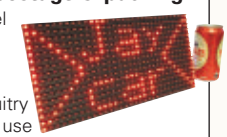
A prototyping shield for the Eleven (XC-4210) and USBDroid (XC-4222) both featured above. Provides plenty of space to add parts to suit any project, keeping everything neat and self-contained. Includes dedicated space to fit a power LED and supply decoupling capacitor.

- Gold-plated surface

Large Dot Matrix Display Panel

XC-4250 $29.00 plus postage & packing

A huge dot matrix LED panel to connect to Eleven, EtherTen and more! This bright 512 LED matrix panel has on-board controller circuitry designed to make it easy to use straight from your board. Clocks, status displays, graphics readouts and all kinds of impressive display projects are ready to create with this display's features.



- 32(L) x 16(W)mm high brightness Red LEDs (512 LEDs total) on a 10mm pitch
- 5V operation
- Viewable over 12 metres away
- Tough plastic frame
- Controller IC's on board, simple clocked data interface
- Arduino compatible library, graphics functions and example support

ProtoShield Short

XC-4248 $3.75 plus postage & packing

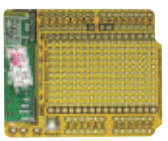
A dedicated short version prototyping shield for EtherTen and EtherMega. This special prototyping shield is designed to fit neatly behind the RJ45 Ethernet jack, allowing you to stack your Ethernet-based projects right on top with standard headers.

- Pads available to fit a reset button
- Gold-plated surface for maximum durability

Receiver Shield 433MHz

XC-4220 $21.75 plus postage & packing

This receiver shield lets you intercept 433MHz OOK/ASK signals, decoding them in software on your Arduino. All the Arduino headers are broken out to solder pads, and GND and 5V rails are provided for convenience.

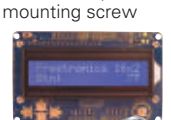


- Reset button
- Blue "power" LED
- Red and green user-defined LEDs
- Gold-plated surface
- 433.92MHz tuned frequency

LCD & Keypad Shield

XC-4218 $21.75 plus postage & packing

Handy 16-character by 2-line display ready to plug straight in to your Arduino, with a software-controllable backlight and 5 buttons for user input. The display is set behind the shield for a low profile appearance and it includes panel mounting screw holes in the corners.



- 2 rows of 16 characters
- Supported by a driver library
- Software-controlled backlight
- Reset button
- Dimensions: 85(W) x 54(H) x 12(D)mm (24mm including header pins)

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3-IN-1 DIGITAL METER ADAPTER FOR GEIGER COUNTERS

The new digital meter adapter (DMAD) from Images Co. is now a universal expansion module. It enhances the capabilities of Geiger counters. Using the TTL digital output pulse from any Geiger counter, it is a:

1) Digital radiation meter, counting radioactive particle detections (pulses) and outputting the equivalent radiation level.
2) RS-232 interface adapter for computer graphing programs.
3) True random number generator.

The DMAD functionality includes a countable pulse resolution and range of one count per minute (CPM) for 9,360 counts per second (CPS). Radiation resolution and range is 1.0 uR/hr, or 655 mR/hr (metric: .01 uSv/hr or 6.5 mSv/hr).

An adapter plugs into the digital out of an analog Geiger counter and provides a random number each time a radioactive particle is detected. The Geiger counter is set up to read background radiation. The random numbers generated are truly random since they are based on naturally-occurring radioactivity.

The random number generator is compatible with analog meter Geiger counters that use either an internal tube or a wand with a shielded cable. Typically — depending on location — the generator will produce 20-40 random numbers per minute. TTL serial output random numbers are sent out via a TTL serial port that may be interfaced to a microcontroller or PC.

The digital adapter also provides an RS-232 computer output for use with Images' Geiger counter graphing program. The Windows Geiger counter program is free to download for non-commercial use only. (Commercial applications must be licensed.)

The module may be purchased as a kit or assembled and tested.

For more information, contact:
Images, Co.
Web: **www.imagesco.com/kits/dmad.html**

SUB-1 GHZ WIRELESS CONNECTIVITY MODULE AND BOOSTERPACK

Anaren, Inc., announces a new sub-1 GHz radio frequency (RF) module, based on the CC110L sub-1 GHz value line transceiver from Texas Instruments. Additionally, Anaren has developed TI's RF BoosterPack plug-in board, containing the CC110L-based module which is compatible with TI's MSP430™ microcontroller (MCU) Value Line LaunchPad development kit.

The new A110LR09A module-based 430BOOST-CC110L RF BoosterPack, provides electronic devices and equipment designers with a speedy and facile way to develop and test wireless solutions using the popular MSP430 LaunchPad environment. The A110LR09A module is a high performance, dual-band FCC-certified and ETSI-compliant radio module that incorporates TI's CC110L low cost transceiver chip in the industry's smallest package (9 x 16 x 2.5 mm). Operating in the ISM bands at 868/915 MHz, the A110LR09A is well-suited for applications such as sensor networks, industrial monitoring and controls, home and building automation solutions, and remote control toys, among many others.

Parallel to this initiative, Anaren will also be offering its own line of AIR-equipped BoosterPacks, featuring many of the company's other AIR modules (including A1101R08A, A2500R24A, and A1101R09A).

As with all AIR modules, the A110LR09A AIR module is designed to help OEMs challenged with adding wireless capability to new or existing devices. Leveraging Anaren's 40+ years in microwave/RF technology and TI's renowned semiconductor technology, the AIR module product family offers:

— Easy integration and implementation on existing or newly-designed two-layer PCBs.
— Tiny common footprints across the product line.
— Pre-certified to applicable standards to save time and

certification costs.
– Choice of embedded or connectorized antenna.
– 100% RF tested in production.
– Low power consumption.
– Same-day connectivity; test boards are available to evaluate each module's performance using TI's development kits (CC1101DK and CC2500DK) and eZ-430 development kits.
– Supplied on tape and reel or matrix trays for easy integration into automated assembly systems.

For more information, contact:
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Web: **www.Anaren.com**

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Global Specialties announces the addition to its product line of the new Model GST-SMT-1.The GST-SMT-1 is a high quality tool kit used to solder and rework surface-mount devices and circuitry. The set includes 11 tools commonly used for working with surface-mount components, such as anti-static tweezers with replaceable tips, suction pen with three different sized tips, soldering iron, and magnifier. The kit comes complete in a convenient molded plastic case. The GST-SMT-1 is perfect for educational experiments, engineering and development, and repair applications. The GST-SMT-1 also can be used to attach surface-mount components to Global's own GSPA-K1 and GSPA-K2 surface-mount adapter kits. The suggested retail price is 79.75.

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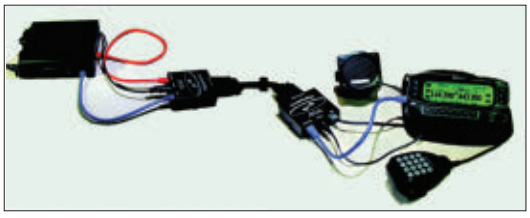
SINGLE-CABLE MULTI-RADIO MOBILE SEPARATION KIT

AE4S, LLC has unveiled SwapMyRigs which standardizes single-cable installations of mobile radios with remotable control.

So you can swap radios without reinstalling cables. By routing all connections through a common cable, any radio with industry standard RJ jacks can be installed or replaced without using manufacturers' proprietary multi-cable separation kits.

The photo illustrates the separation of a Kenwood TM-D710 transceiver from its remote controls. SwapMyRigs consists of two small field-configurable powdercoated steel boxes called SMRs; one is at the transceiver, the other is at the remote location, connected by a standard



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By Dev Gualtieri

BUILD A STEREO GAIN CONTROLLER

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

One consequence of the 2009 transition to digital television in the US is that I lost most of the New York City television stations I had watched for the last 30 years. Since I live in a far New Jersey suburb, I wasn't able to get strong, multipath-free signals on the new UHF channels used for broadcasting the digital signals. I had never felt a need for cable television but it suddenly became a necessity. So, I opted for the fiber optic service available in my area.

The video reception on cable was terrific — since I bought an HD television at the same time — but the audio was an enigma. There was a tremendous variation in volume going from one channel to another, and the commercials seemed too loud. We never had such problems with off-the-air signals. That's because broadcasters can't risk transmitter over-modulation. At the same time, they want to keep their signals as high as possible to cover a wide audience. These competing demands force them to keep firm control of their audio signals. That doesn't seem to be the case for cable.

What does an electronic hobbyist do when faced with a technical challenge like this? He heads for the parts drawer and a soldering iron! Fortunately, I had a short career as a broadcast engineer so I knew a lot about the technology of automatic volume control. I also knew that I didn't want to build a compressor or a limiter. I really wanted a platform gain controller.

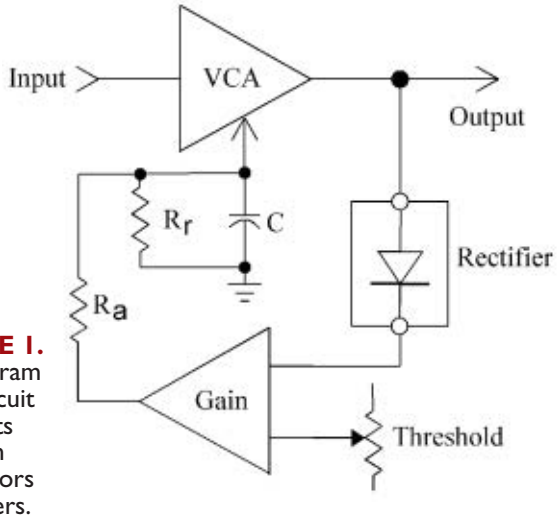


FIGURE 1. Block diagram of the circuit elements of both compressors and limiters.

Compressors and Limiters

Circuits to regulate the amplitude of audio signals have been around since the vacuum tube days. They were patented as early as 1932 (H. A. Wheeler, "Volume Control," U.S. Patent No. 1,879,863, September 27, 1932). The most common types of audio gain controllers are compressors and limiters. A compressor modifies the dynamic range of an audio signal to make quiet passages louder and loud passages softer. As a side effect, it makes the audio signal sound louder overall. A limiter functions somewhat like a compressor, but it's designed to pass signals unchanged up to a threshold and then completely block signals from rising in amplitude above the threshold.

Figure 1 is a block diagram of the circuitry involved for both compressors and limiters. The differences between these is the threshold at which the device starts to control and the gain of the amplifier that drives the control signal

for the voltage-controlled amplifier. There is also a difference in the attack time constant (RaC) and release time constant (RrC) of the RC filter in the control loop.

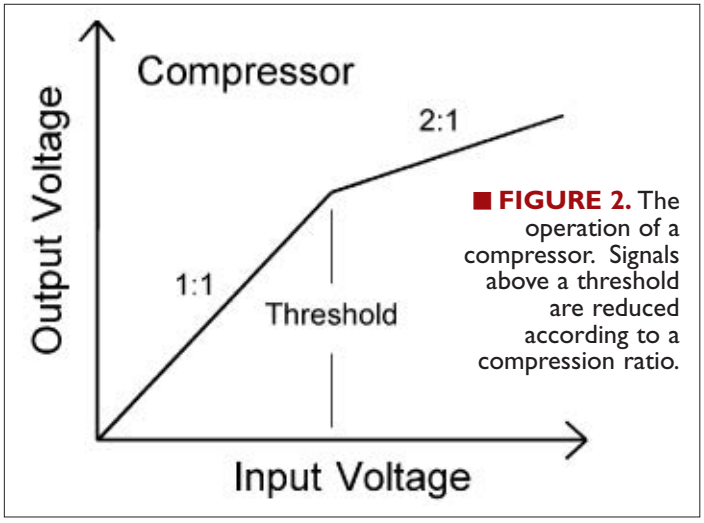
The attack time for both compressors and limiters is fast (< 1 msec), but a compressor has a longer release time than a limiter. The release time in a compressor is usually of the order of a few hundred milliseconds, but for a limiter it can be shorter than 10 milliseconds.

The operation of a compressor is shown in **Figure 2**. At signal levels below a threshold, the input and output levels track each other and the audio is unchanged. Above the threshold, increasing the input level causes a smaller change in output level. The ratio of input signal change to output signal change is called the compression ratio. A 5:1 ratio means that a five dB increase in signal amplitude gives just a one dB increase in output. In this way, loud signals are suppressed.

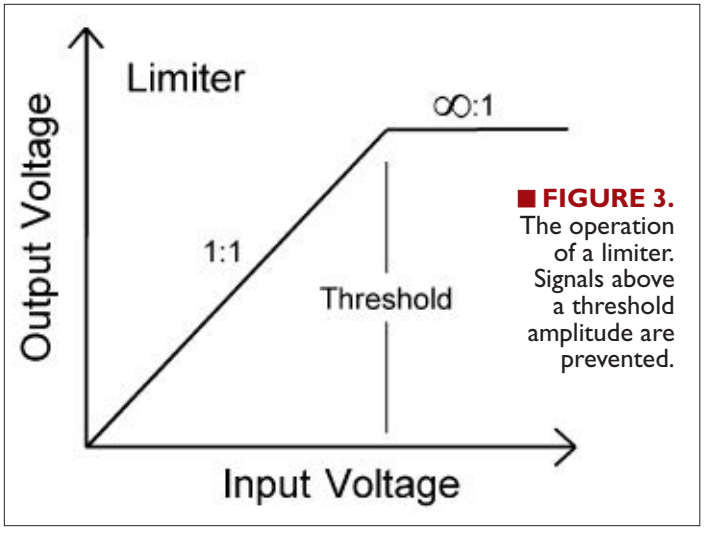
A large compression ratio will effectively suppress loud signals, but there are problems with too high a ratio. First, you'll have no dynamic range for your audio, and everything will sound too loud. There's also too much amplification of low level signals that leads to what's poetically described as "whoosh." Whoosh is the sudden insult of system noise you'll hear during pauses in the audio signal; for example, between sentences in speech or between songs. Aside from the whoosh problem, when the input signal reappears the attack time might be slow enough to let a short over-amplitude burst pass through.

A high compression ratio also leads to waveform distortion at low frequencies. What happens is that the compressor tries to level the peaks and valleys of the audio waveform itself. For such reasons, smaller compression ratios are used. Since this isn't wholly effective in preventing over-modulation of transmitters, the compressor is followed by a limiter that absolutely prevents any signals from going higher than a predetermined level.

The way a limiter processes audio is shown in **Figure 3**. The action is just like a compressor below the threshold — there's no change in the signal. Above the threshold, a limiter acts like a compressor with a very high compression ratio, essentially infinity. A limiter is designed to absolutely block any signals above the threshold. Since limiters follow compressors in an audio chain, the compressor does most of the work and the limiter acts as a safety valve. In proper operation, a limiter rarely goes above its threshold, and it doesn't contribute to whoosh.



■ **FIGURE 2.** The operation of a compressor. Signals above a threshold are reduced according to a compression ratio.



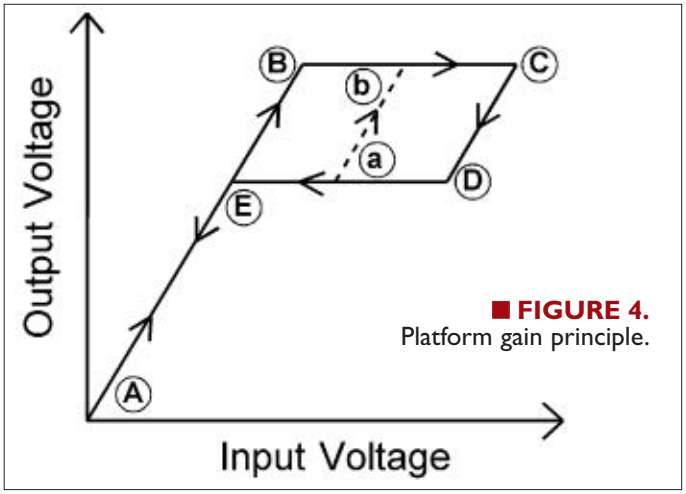
■ **FIGURE 3.** The operation of a limiter. Signals above a threshold amplitude are prevented.

Platform Gain Principle

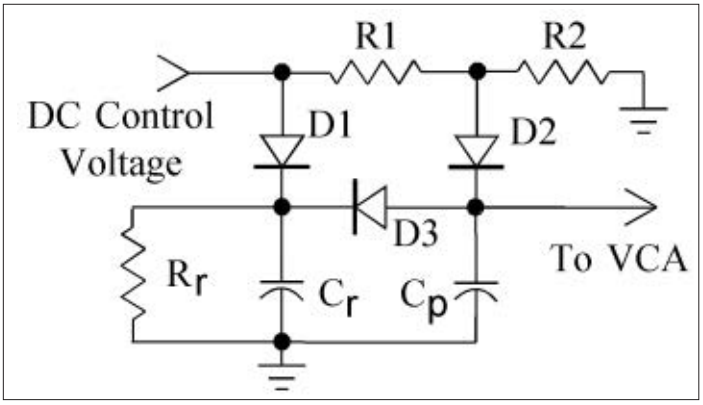
A compressor followed by a limiter was the usual signal processing chain for most broadcast stations until the 1960s. At that time, a new type of audio controller hit the market and started to dominate. This was the platform gain controller, conceived by CBS Labs. CBS — a major television and radio network with many corporate-owned stations — had a vested interest in advancing broadcast technology. CBS Labs was started in 1936, and it operated in one form or another for 50 years. A CBS Labs employee, Dennis Gabor, even received a Nobel Prize in Physics, although it was for work in holography not related to CBS Labs activities.

In 1959, CBS Labs introduced the first platform gain controller — the Audimax Audio Gain Controller — that was designed to replace compressors. CBS Labs also introduced a Volumax line of audio limiters. These were still the vacuum tube days, and the patents on the platform gain principle — now long expired — show that (B.B. Bauer and Arthur Kaiser, Gain Control Apparatus Providing Constant Gain Interval, US Patent No. 3,187,268, June 1, 1965; Arthur Kaiser and Emil Torick, "Compensated Platform Gain Control Apparatus, US Patent No. 3,260,957, July 12, 1966; Emil Torick and Arthur Kaiser, Control Circuit for Restricting Instantaneous Peak Levels in Audio Signals, US Patent No. 3,398,381, August 20, 1968).

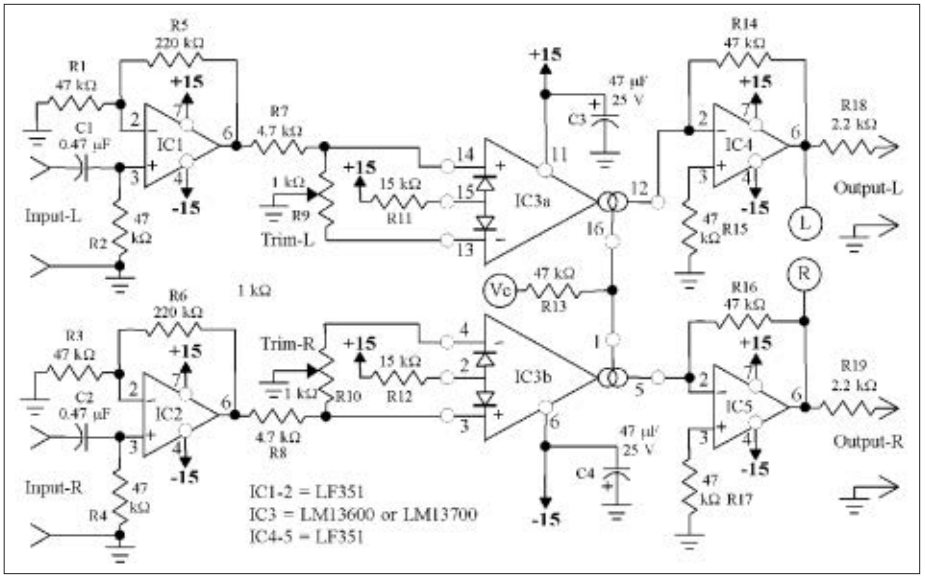
The platform gain principle is shown in **Figure 4** which has some similarity to the limiter transfer function of **Figure 3**, with a strange twist. Just as for a limiter, signals below a threshold are passed without modification, and any signals above a threshold are blocked. That's when the signal is increasing, as from point B to point C. When the signal



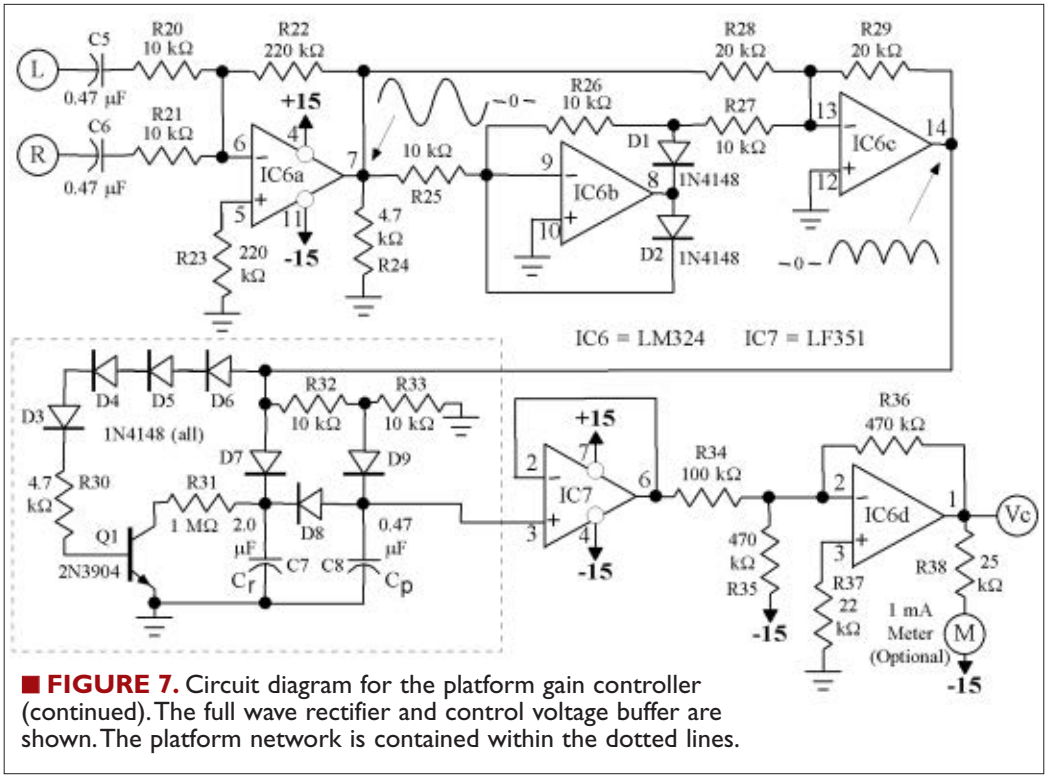
■ **FIGURE 4.** Platform gain principle.



■ **FIGURE 5.** Diodes and other circuitry are added to the resistor-capacitor time constant circuitry in a limiter to produce the platform effect.



■ **FIGURE 6.** Circuit diagram for the platform gain controller. The voltage-controlled amplifier and input-output buffers are shown.



■ **FIGURE 7.** Circuit diagram for the platform gain controller (continued). The full wave rectifier and control voltage buffer are shown. The platform network is contained within the dotted lines.

pulls back from its peak at point C, the output changes in a 1:1 correspondence with the input, as it did before the threshold was reached.

It's only when the input signal is reduced quite a bit (at point D) that the gain control kicks in to maintain the output at a higher signal level. Finally, if the input signal is reduced quite a bit, at point E the output tracks the input. If somewhere in between — from point A to point B — the input level again increases, it takes a measured increase in the input signal before the gain control again kicks in to prevent over-modulation. The regions B-C and D-E are the gain platforms, and the signal level difference between these two platforms sets the dynamic range for the controller. What all this means is that the dynamic range is preserved, while at the same time peaks are prohibited and average volume is kept high. The circuit effectively acts like a careful engineer who turns up the volume when the signal is too low, and turns it down when it gets too high.

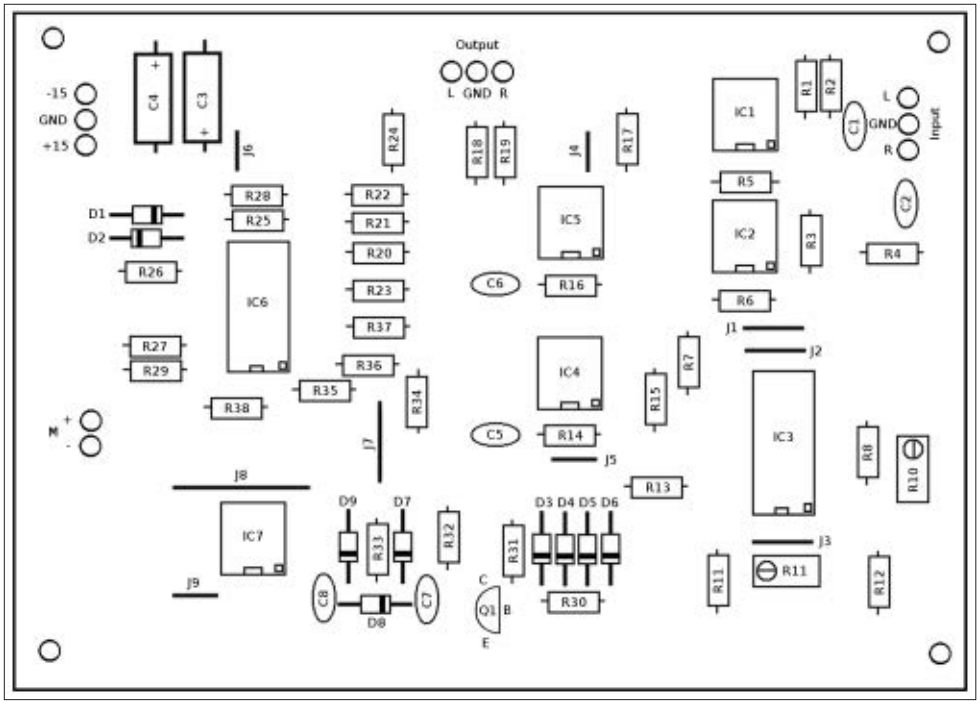
Circuit

Some magic tricks are done with mirrors. The

platform gain trick is done with diodes.

We replace the simple resistor-capacitor time constant circuitry in a limiter with the network shown in **Figure 5**. As you can see in the figure, there are two capacitors; one of which is driven with a reduced voltage from a voltage divider composed of resistors R1 and R2. When resistor R1 is equal in value to resistor R2, the voltage on capacitor C_r is twice that of C_p. That means that on any peak in the audio, C_r will always be at a higher voltage than C_p.

Since the only connections to C_p are to the diodes and the high impedance input of the VCA, this capacitor has no discharge path, so it will hold the peak voltage. C_p will discharge only when the voltage on C_r goes lower than the voltage on C_p. That's the only time when both capacitors can discharge through R_r. It's the voltage difference between the two capacitors — set by the ratio of R1 and R2 — that fixes the gain platform. With equal values for R1 and R2, the platform is set for 50%, or 3 dB. **Figure 6** and **Figure 7** show the circuit diagram for the platform gain controller.



■ **FIGURE 8.** Parts placement on the component side of the platform gain controller circuit board.

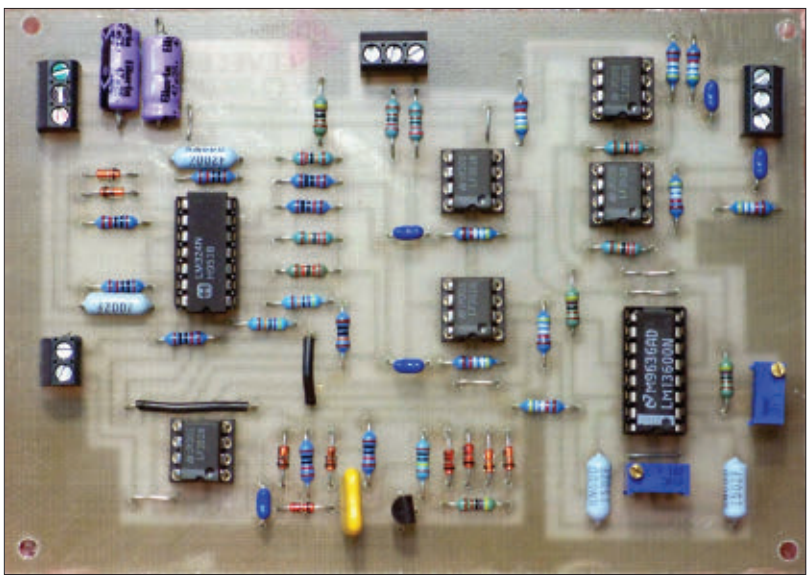
Printed Circuit Board

A printed circuit board layout that uses just a single copper plane is available with the article downloads; a parts placement diagram on the component side is shown in **Figure 8**. **Figure 9** is a photograph of the populated circuit board, and **Figure 10** shows the external connections to the circuit board, including one possible way to implement the power supply.

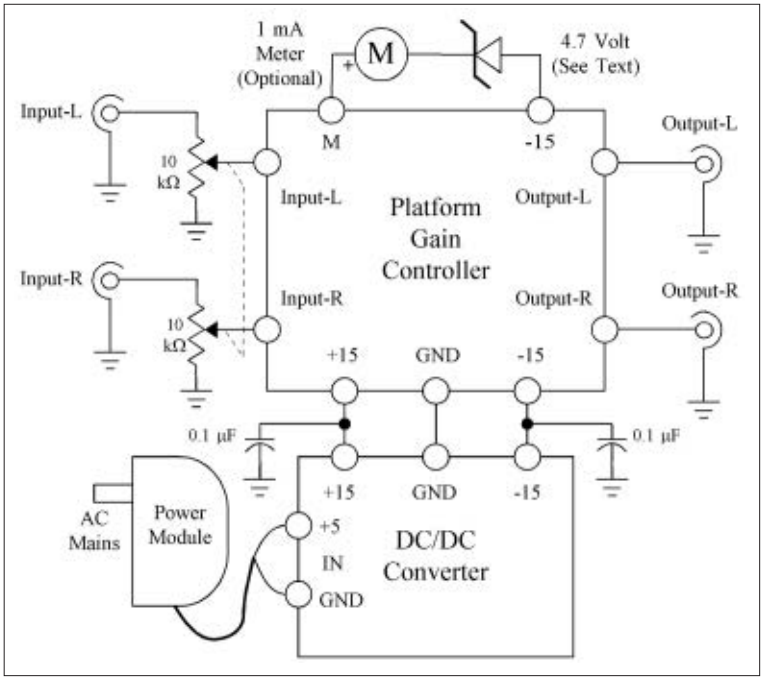
The current requirements for the positive and negative voltages are quite low — less than 25 mA each. Probably the best way to power the controller (as shown in the **figure**) is with a wall wart power supply feeding a DC-DC converter. One possible converter to use is a Murata NMH0515SC two watt converter that converts a five volt supply to ±15 volt supplies of 67 mA each. Use a regulated five volt wall wart, use the recommended bypass capacitors, and keep the converter away from the low level audio stages. Such converters do generate a little EMI.

The input pots should be of the "audio taper" variety, meaning you get more control at higher attenuation than with a linear pot. A ganged pot is preferred over two separate pots, but if this is in a set-and-forget application, that's not too essential. The meter (which is optional), is driven by the control voltage signal, so it always has a little bias voltage on it. I removed this with a zener diode (as shown in **Figure 7**), but many analog meters have a mechanical zero that will do just as well. My controller — which has an LED bar graph display instead — is shown in **Figure 11**. This was built into the box of a surplus oscilloscope plug-in module. Waste not, want not!

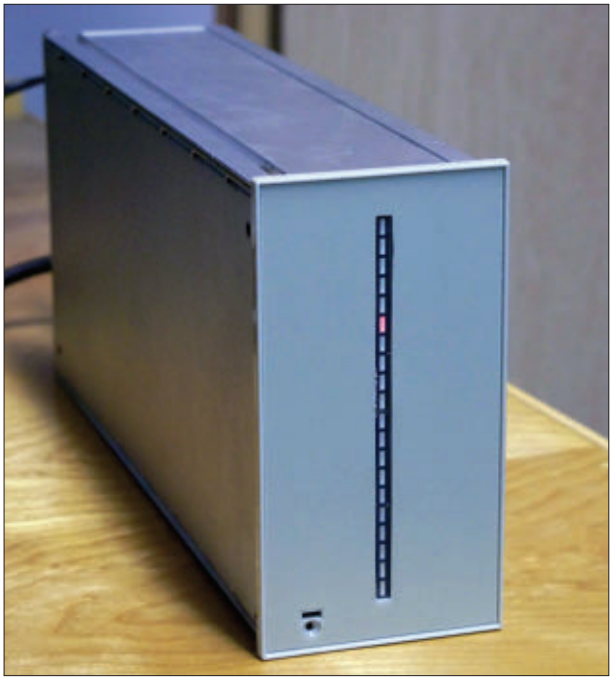
Figure 12 shows the meter calibration for my unit using the series zener diode. **Figure 13** is artwork for the meter scale used in one of my controllers. Normal signal levels put the needle in the blue band. The scale is in dB gain reduction, which means that negative values — towards the top of the scale — indicate that the gain has been increased. Positive values — at the bottom of the scale — show that the gain has been reduced.



■ **FIGURE 9.** Photograph of the populated circuit board.



■ **FIGURE 10.** External connections to the circuit board, including one possible way to implement the power supply.



■ **FIGURE 11.** The controller — which has an LED bar graph display — was built into the box of a surplus oscilloscope plug-in module.

Circuit Operation

Referring to the circuit diagrams in **Figure 6**, the gain control element (IC3) is an LM13600 dual operational transconductance amplifier. This chip functions as a voltage-controlled amplifier with a current source-sink output. Fortunately, the chip has an internal current-voltage converter that makes it suitable as a stand-alone VCA for most applications. The simple current-voltage converter that's used in this chip is not exactly suitable for professional audio applications, so a revised chip with better circuitry — the LM13700 — was introduced.

There are, however, still many sources for the older LM13600 chip (including my parts drawers), so the controller circuit adds its own current-voltage converters that allow the circuit to operate with either chip. These converters — which are just operational amplifiers (IC4-5) — also double as convenient output buffer stages. Other operational amplifiers (IC1-2) buffer the inputs. The circuit is socket compatible with the LM13700.

This is a stereo gain controller which is not exactly the same as two monaural gain controllers in the same box. In stereo, it's important to maintain the stereo image, which is the virtual location of sound sources in the audio. In classical music, especially, you don't want to have the violins or horns wandering all over the sonic space. For this reason, the control voltage for the processor is derived from the sum of both stereo channels. IC6a is the summer. The gain is reduced or enhanced in both channels simultaneously.

Rectification of the audio to obtain a DC control signal is done by a full wave rectifier built around IC6b-IC6c. This signal is fed to the platform circuit, and the peak holding capacitor Cp is buffered by a high impedance amplifier, IC7. A level-shifter derives a control voltage that's suitable for the VCA and an optional meter.

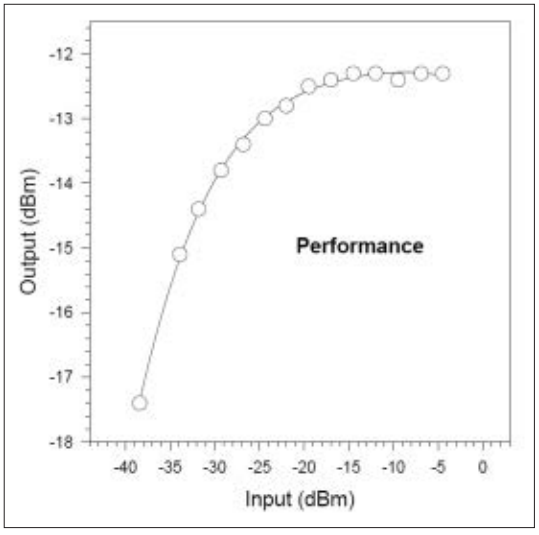
You'll notice that the platform circuitry is slightly

PARTS LIST

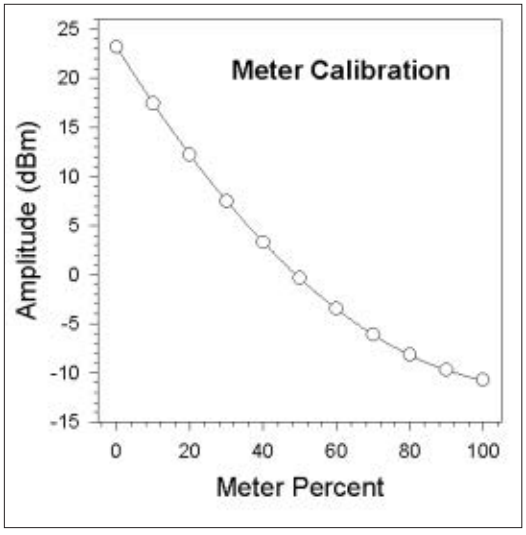
ITEM	DESCRIPTION
R1-R4	47K
R5, R6	220K
R7, R8	4.7K
R9, R10	1K , 20 turn Trim Pot
R11, R12	15K (Note 1)
R13-R17	47K
R18, R19	2.2K
R20, R21	10K
R22, R23	220K
R24	4.7K
R25-R27	10K
R28, R29	20K (Note 2)
R30	4.7K
R31	1 M
R32, R33	10K
R34	100K
R35, R36	470K
R37	22K
R38	25K (Note 3)
C1, C2	0.47 F, 35V
C3, C4	47 F, 25V
C5, C6	0.47 F, 35V
C7	2.0 F, 35V (Note 4)
C8	0.47 F, 35V (Note 4)
D1-D9	1N4148
IC1, IC2	LF351N
IC3	LM13600N or LM13700N
IC4, IC5	LF351N
IC6	LM324N
IC7	LF351N
Q1	2N3904 NPN
Meter (Optional)	1 mA
Power	±15 V @ 25 mA (Note 5)

Other:
1 - Dual 10K Audio Taper Potentiometer
4 - RCA Style Audio Connectors (Female)
IC Sockets: Five eight-pin, one 14-pin, one 16-pin
Breadboard, Chasis, misc. hardware

Notes:
1) Can be a parallel combination of 22K and 47K.
2) Can be a series combination of two 10K resistors.
3) Can be a parallel combination of of 33K and 100K.
4) Non-electrolytic capacitor. Polypropylene, polystyrene, or Teflon preferred.
5) Best power supply is a five volt wall wart with a two watt 5V/±15V DC/DC converter.



■ **FIGURE 14.** The input-output transfer function of the platform gain controller when the input signal is always increasing. A very high output level is maintained over a very large change in input level.



■ **FIGURE 12.** Meter calibration for the unit when the series zener diode is used.

more complicated than what we discussed earlier in the article. There are a few more diodes and a transistor. The diode connection — four diodes (D3-D6) in series — may seem strange. The reason for this is that we're taking advantage of the fact that diodes are not ideal rectifiers. Silicon diodes have a threshold voltage of about 0.7 volts, below which they don't conduct well. Four diodes in series will bump that threshold up to nearly three volts. The reason for the diodes and the transistor that they drive is to add a "gate" function to the platform gain controller. As we know from our discussion of compressors, when the audio input signal is removed (as for the natural pauses in speech) the noise whoosh kicks in. The gate prevents the release capacitor from discharging through R31 during such pauses. The controller holds its last gain state.

Tuning and Performance

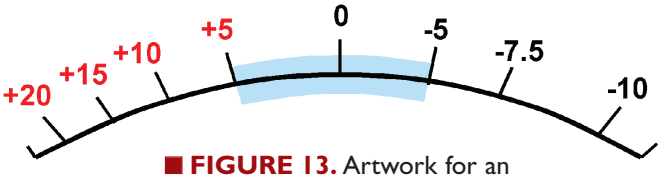
Once the circuit is assembled and passes the smoke test, it's time to adjust the trim pots R9 and R10. These pots balance the DC input currents of the operational transconductance amplifier. Since the outputs are DC coupled, this is done by putting a voltmeter at the left channel output, adjusting R9 for very close to zero volts, and then doing the same for the right channel and R10. If this isn't done correctly, you might force the processor into a very low gain state when you first apply an audio input. That's because the DC "thump" will be processed as a very large change in the input signal.

Figure 14 shows the input-output transfer function of the processor when the input signal is always increasing. You can see how a very high output level is maintained over a very large change in input level. If we decrease the input voltage, the signal would need to drop by 3 dB before leveling off, because of the gain platform.

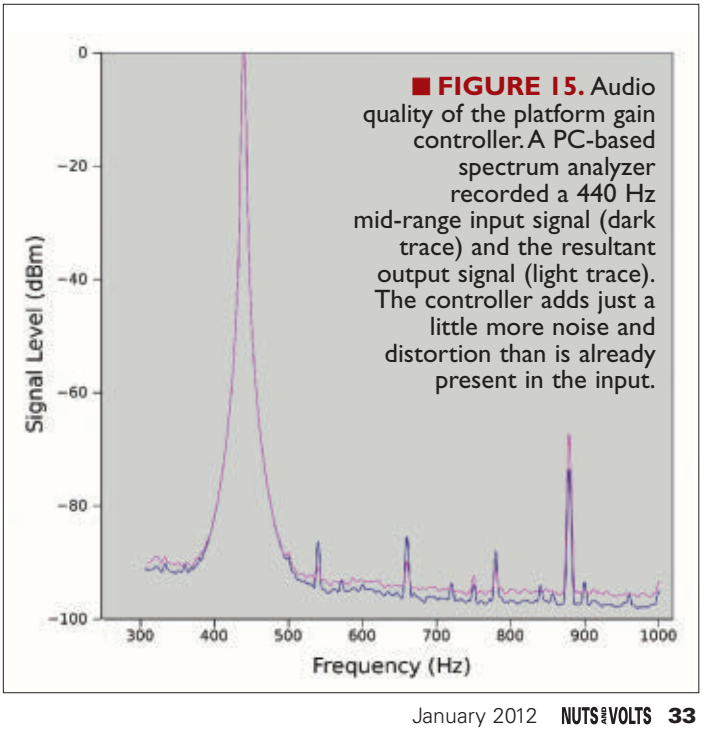
Figure 15 gives you an idea of the audio quality of the platform gain controller. The spectra shown in the figure are taken using Audacity — an open source audio editing and processing program that works on both Linux and Windows. I use the Linux version. Voltage-controlled amplifiers are notorious for introducing distortion and noise, but the LM13600 seems well behaved.

The dark trace is the oscillator input to the controller, set at 440 Hz and a voltage to reach the controller operating midpoint. The light trace is the controller output. The controller adds just a little more noise and distortion than is already present in the laboratory-quality audio oscillator, or added by the PC sound card used as an input device. The second harmonic of 440 Hz is 880 Hz. Some of the extraneous peaks are from power line harmonics on the signal leads — the bane of any audio engineer.

Well, that wraps things up. I hope you've 'gained' some insight into stereo gain controllers. NV



■ **FIGURE 13.** Artwork for an analog meter scale.



■ **FIGURE 15.** Audio quality of the platform gain controller. A PC-based spectrum analyzer recorded a 440 Hz mid-range input signal (dark trace) and the resultant output signal (light trace). The controller adds just a little more noise and distortion than is already present in the input.

BUILD THE GARAGE DOOR CLOSER

By Brian Beard

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

Automatic garage door openers can be a real blessing. I know, I feel that way every time I drive home in the rain. As convenient as they are, they are also a potential danger. Everyone — at one time or another — has gotten distracted and failed to close the garage door. An open garage door is an invitation for thieves and vandals. And don't forget the mischief birds, cats, raccoons, and other animals can cause in your garage. So, I decided it was time to build a circuit that would close my garage door when it was unintentionally left open.

Investigating My Automatic Garage Door Operator

My goal was to design an automatic closer circuit that was simple and reliable. Because it is a safety device intended to compensate for my forgetfulness, I didn't want to power it with batteries that I would have to remember to change in the first place. If the closer could be powered by the garage door opener itself, that would be ideal. I have a Genie radio-controlled automatic garage door operator. Like every automatic garage door operator, it also has a local normally-open pushbutton to open and close the door.

The Genie manual instructs the installer to connect the local pushbutton to the two screw terminals labeled PUSH BUTTON and COMMON. Using a voltmeter, I measured 19 VDC between COMMON and PUSH BUTTON. Using an oscilloscope, I observed this voltage to have approximately 2V of ripple (18V-20V) with peaks about every 8.3 milliseconds, suggesting it is the output of a full

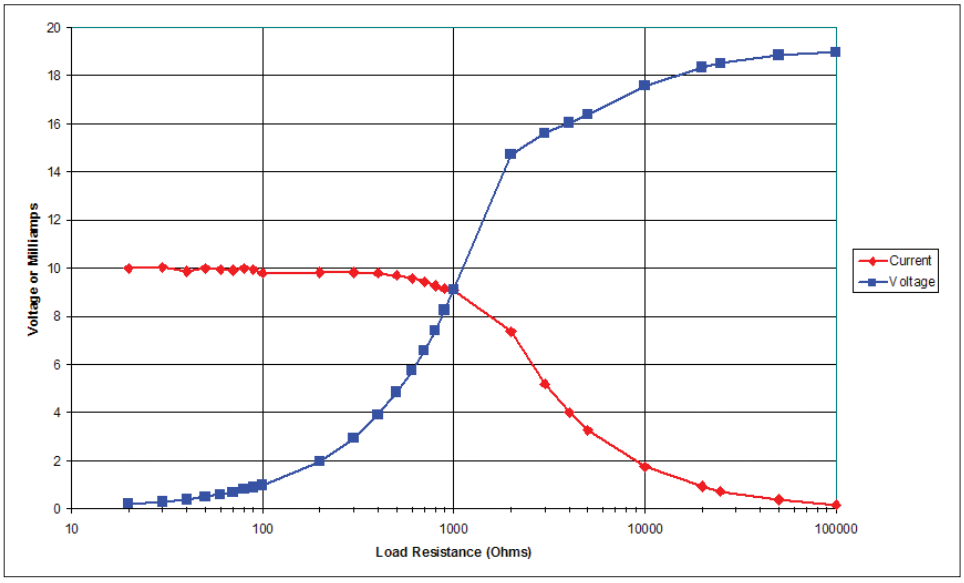


FIGURE 1. Voltage and current available on the PUSH BUTTON output of my Genie garage door operator as a function of load resistance.

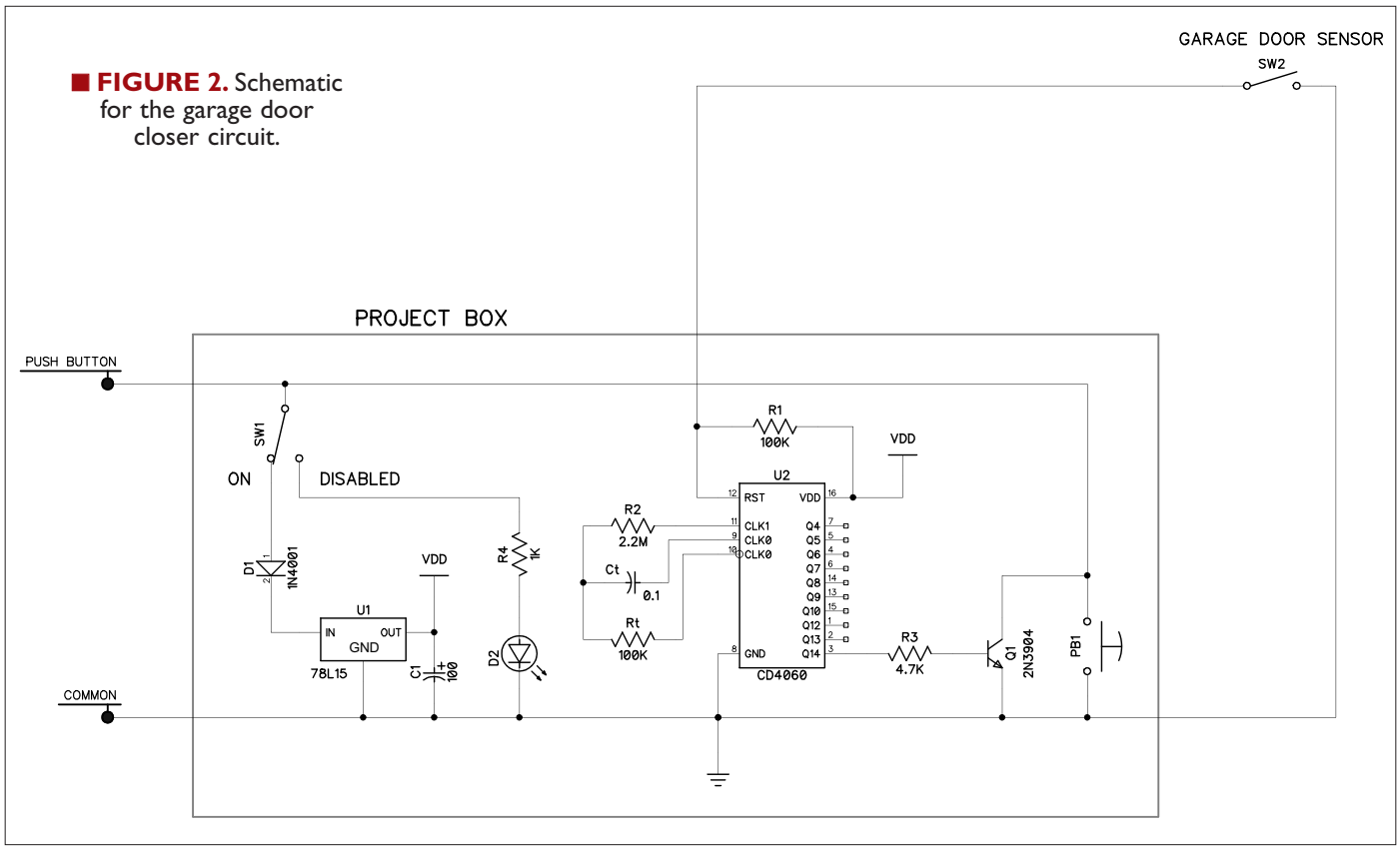


FIGURE 2. Schematic for the garage door closer circuit.

wave rectifier. Placing a variable load between PUSH BUTTON and COMMON, I recorded the voltage and current as a function of the load resistance (**Figure 1**). The garage door opener didn't trigger until the PUSH BUTTON voltage was 0.3V or less. The maximum current of 10 mA available from PUSH BUTTON told me a low power closer circuit could be powered from that line.

Design and Build

I designed the closer circuit using a CMOS 4060, 14-stage binary counter and oscillator, shown as U2 in **Figure 2**. The datasheet gives the formula for the oscillator frequency as Fosc = 1/(2.3*Rt*Ct). The values shown in the schematic approximate a frequency of 43 Hz. A 14-stage binary counter can count to 16K which means the most significant bit's output (Q14) will go high at count 8192. When Q14 goes high, it turns on transistor Q1which grounds the PUSH BUTTON input to the automatic garage door opener, causing the garage door to close.

How long does that take? At 43 Hz, the period (one count) is 23.25 milliseconds; 8192 counts = 190.5 seconds = 3 minutes and 10.5 seconds. Note that when Q1 turns on, it effectively shorts out the power supply for the closer circuit. The Vdd supply for U2 must persist long enough for the automatic garage door operator to react to the short on PUSH BUTTON. C1 stores enough charge to keep Q1 turned on for more than 100 milliseconds. D1 prevents reverse current flowing from C1 through U1.

Speaking of Vdd, the 4XXX series of CMOS logic is designed to operate from three to 15 volts. I included the 78L15 (U1) low power linear regulator to insure that Vdd

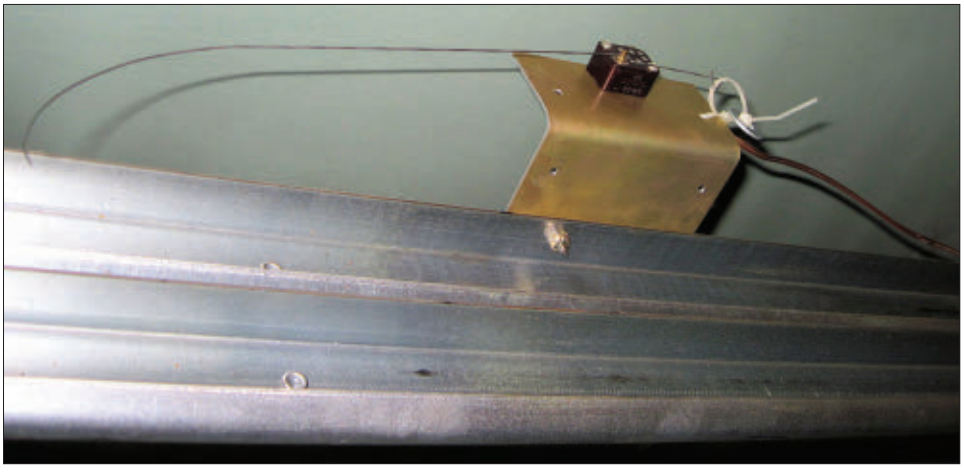
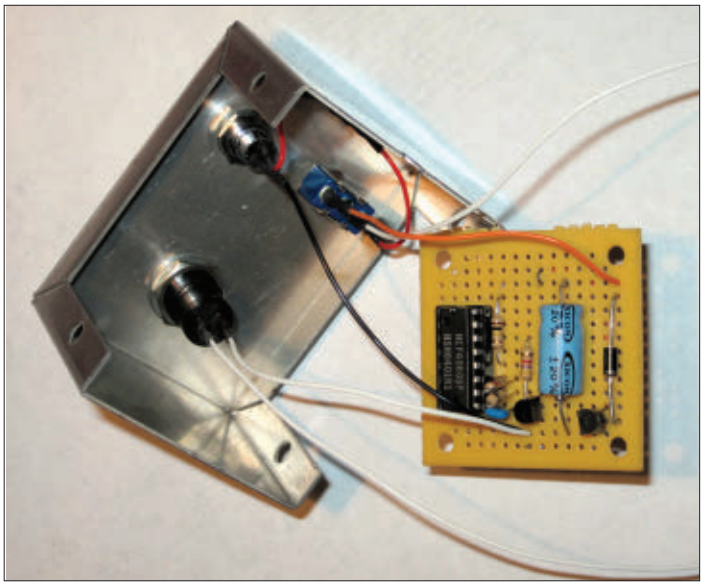


FIGURE 3. Door open sensor switch with music-wire feeler mounted on the garage door track.



■ **FIGURE 4.** Garage door closer circuit mounted inside a project box.

did not exceed the maximum operating voltage. When I want to keep the garage door open for an extended period — like when I am mowing the lawn or washing the car — I can flip switch SW1 to the disable position. This removes power from the closer circuit and lights a red LED warning me the closer is disabled. Even when the closer circuit is disabled, the garage door can still be opened or closed by pressing pushbutton PB1. When you think about it, the closer circuit is nothing more than a fancy way of pressing the local pushbutton (PB1).

One thing I haven't mentioned yet is how the closer circuit detects when the garage door is open. This is done via switch SW2 shown in **Figure 3**. I am using a normally-open rotary switch connected to a piece of music wire. When the garage door is closed, SW2 is open and the reset pin of the 4060 is pulled high by R1. When the garage door reaches the top of its travel, it pushes against the left end of the music wire which rotates the shaft of SW2 by 90 degrees, causing it to close. When SW2 closes, it grounds the reset pin of the 4060 allowing the count to start from zero.

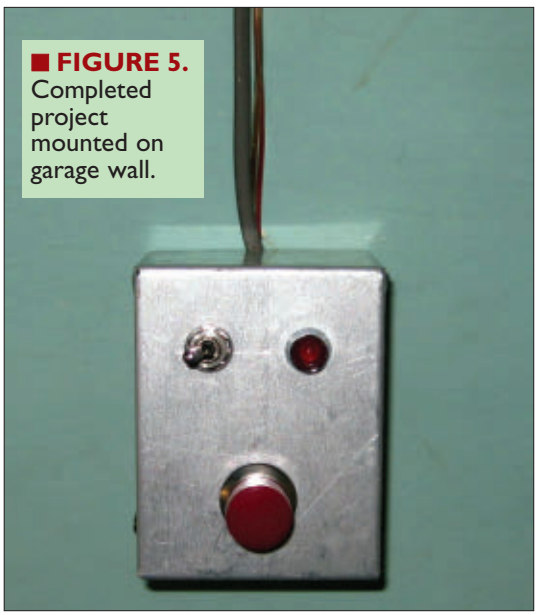
I built the closer circuit on a small perf board (RadioShack 276-148) shown in **Figure 4**. The perf board and the manual controls were installed in a small (2.5 x 2 x 1.5 inch) aluminum project box that I mounted on my garage wall (**Figure 5**). This was a fun project to build. It's actually useful and it doesn't even use a microcontroller!

Building Your Own

If you are thinking of building your own garage door closer circuit, here are some things you should consider:

- Check the voltage and current available at your automatic garage door operator's local pushbutton. Depending on the voltage available, you may want to use a 78L12 or 78L05 instead of the 78L15.
- Determine the voltage and duration of the pulse needed to trigger your automatic garage door operator; mine was 0.3V or less for 100 milliseconds.
- Note that a CMOS 4060 can operate from three to 15 volts. A 74HC4060, on the other hand, can operate from two to six volts.
- The closing time for my circuit varies from three minutes and 15 seconds in the summer to three minutes and 45 seconds in the winter. I did not use temperature stable components. If you want a more consistent closing time, use temperature stable precision components for Ct and Rt.
- Shorter closing delays can be achieved by using one of the 4060's less significant outputs — like Q12 or Q10 — or by increasing the frequency of the oscillator.
- Longer closing delays can be obtained by connecting the Q14 output of the 4060 to the clock input of another counter — like a 4040, 12-stage binary counter. If you do this, be sure to connect the reset pin of the 4040 to the reset pin of the 4060 so both chips start counting from zero.
- I used a rotary microswitch to detect the garage door was open because I happened to have it available. A magnetic switch — like those used as door and window sensors in alarm systems — would probably be more reliable in the long run.

Hope you find this circuit as handy as I do.
NV



■ **FIGURE 5.** Completed project mounted on garage wall.

PARTS LIST

QTY	PART	REFERENCE
1	100 µF, 35V	C1
1	0.1 µF, 35V	Ct
2	100K, 0.25W, 5%	R1, Rt
1	2.2M, 0.25W, 5%	R2
1	4.7K, 0.25W, 5%	R3
1	1K, 0.25W, 5%	R4
1	1N4001	D1
1	LED, red	D2
1	2N3904	Q1
1	78L15	U1
1	4060	U2
1	DPST toggle	SW1
1	Door sensor	SW2
1	Pushbutton	PB1

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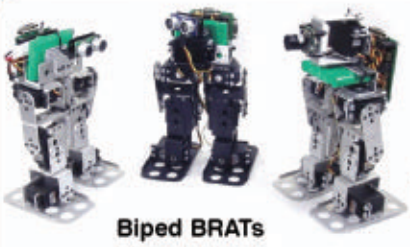

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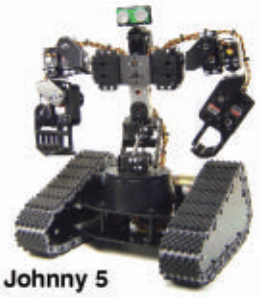
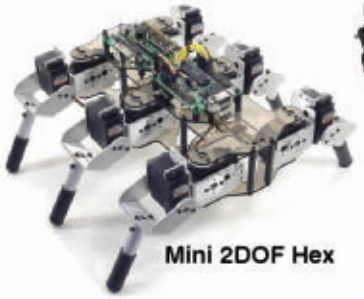


Johnny 5

Round 3DOF Hex

A4WD1



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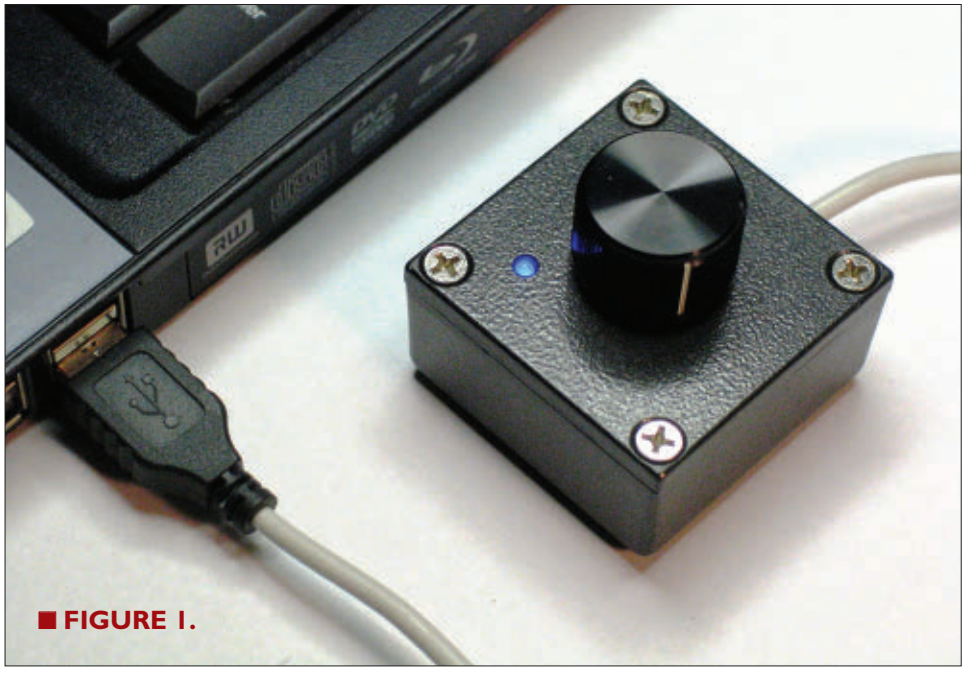


■ FIGURE 1.

No Programmer Required!

By Richard Dzioba

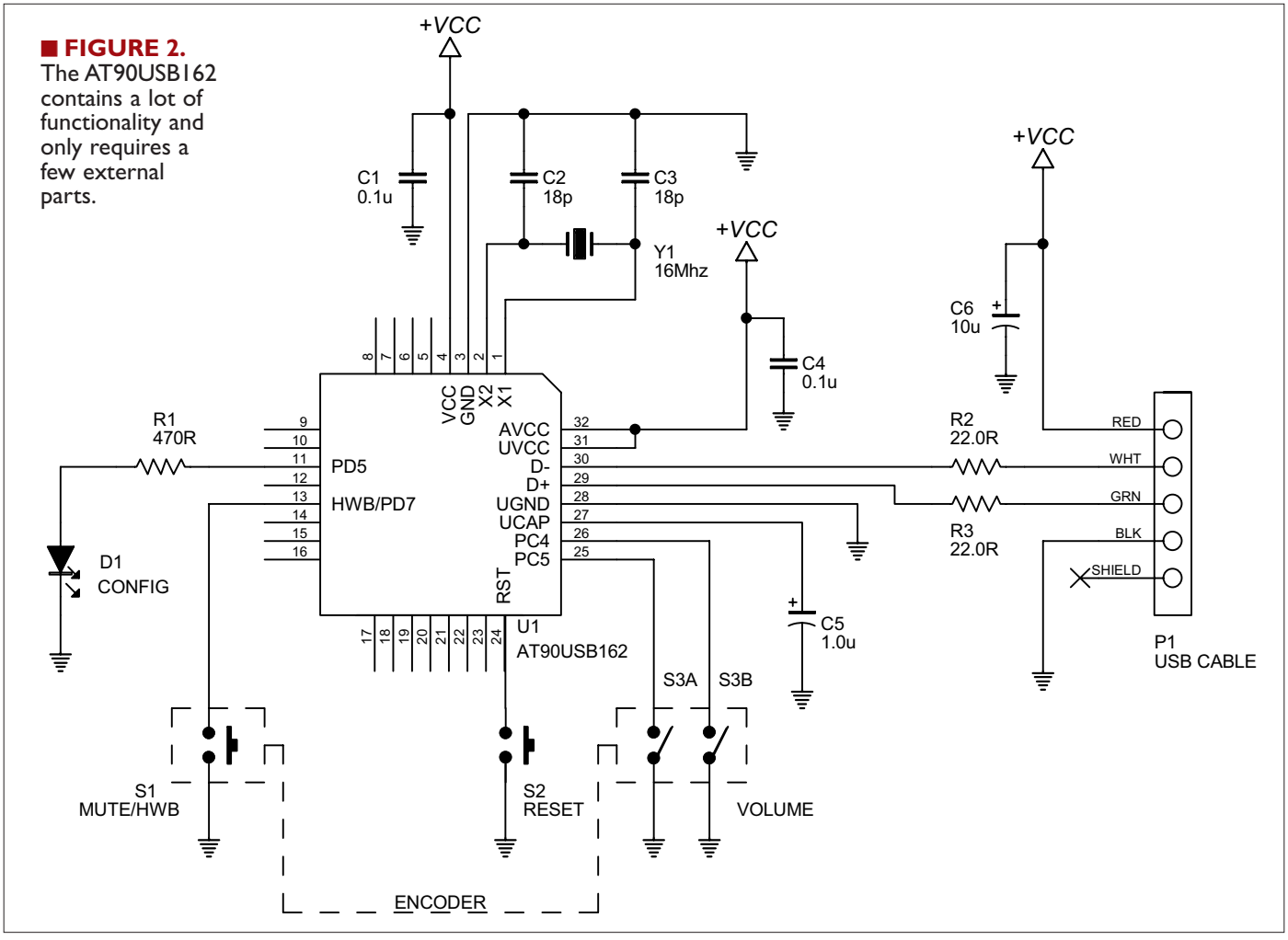
Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

This project started out from a need to add externally adjustable volume and mute capability to my laptop computer. I listen to a lot of music and found that the existing touch-sensitive volume slider control on my laptop did not make it easy to do fine volume control adjustments. Plus, if I wanted to listen to music with the laptop lid closed, the volume controls were inaccessible and there was no way to hit the mute button. I needed an external control that was compact, powered from the USB port, and would not require any special drivers to be installed.

You are probably thinking "why not just get an MP3 player and your problems are solved?" Yes, that's true. However, but if you are an avid electronics hobbyist, you know that isn't how it's done. Simple solutions are not as much fun as a project! Here was a good opportunity to learn about USB and end up with something of practical use. See my solution in **Figure 1**.

DESIGN

I chose the AT90USB162 microcontroller from Atmel's AVR eight-bit line for this project. It has both a general-purpose microcontroller and a USB function controller in one chip. It can be powered from the USB port, so no additional power supply is needed. As an added bonus,



■ FIGURE 2. The AT90USB162 contains a lot of functionality and only requires a few external parts.

the AT90USB162 comes with a Device Firmware Update (DFU) bootloader that allows you to program the device using the USB port. All you need to do is download, install, and run Atmel's free DFU programmer software to load the firmware supplied with this article; no external programmer is required.

Once programmed, when the device is connected to a USB port it will tell Windows to automatically install the correct driver and your volume/mute controller will be up and running. Pretty neat!

The AT90USB162 is really a USB "toolkit." It contains a USB Serial Interface Engine (SIE) that manages all of the basic USB communications functions:

- Error detection and correction.
- Data encoding and decoding.
- Bit stuffing and unstuffing.
- USB packet generation.

This takes away a lot of complexity from the software, leaving the implementation of the USB protocol and managing the encoder and pushbutton used for the volume control and mute. Only a few external components are needed to complete the design. Refer to the schematic in **Figure 2**.

A rotary encoder is used for data entry. The encoder controls the volume and the part specified contains a pushbutton switch that is activated by pressing down on the encoder shaft for the mute function. This keeps the overall design very compact.

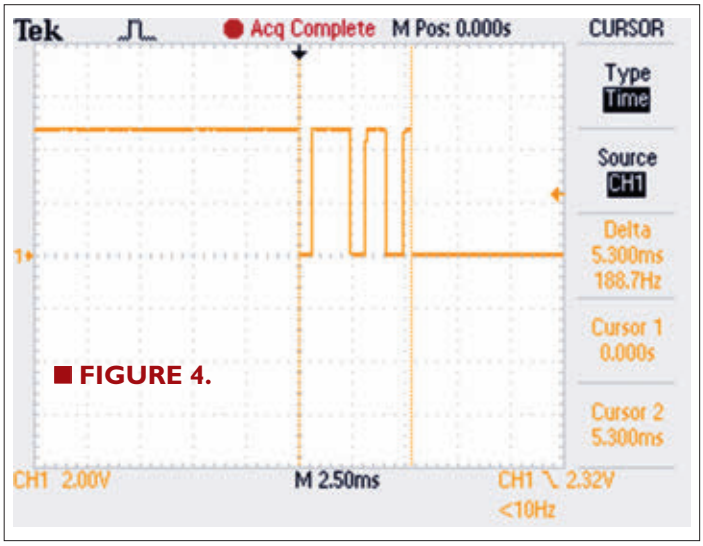
HUMAN INTERFACE DEVICE

I planned the project around the USB Human Interface Device (HID) class driver built into the Windows operating system — no additional drivers are required. The HID class specification describes all sorts of devices including mice, keyboards, and joysticks, and includes the media controls needed for this project.

All of the information needed to identify our device as a HID is stored in the device's programmable memory in a data structure called a descriptor. Within the descriptor, there is an additional structure called a report that describes the features in the host's operating system that are to be controlled. The report for our device brings together some useful media controls and is one byte in

Media Control – Report Bit Number Assignments							
Next Track	Prev Track	Play	Pause	Stop	Vol +	Vol -	Mute
7	6	5	4	3	2	1	0

■ **FIGURE 3.** The device implements just volume and mute but if you are adventurous, you can hack the supplied source code to implement the other media controls shown.



■ **FIGURE 4.**

length. Each bit — called a usage in USB language — defines a particular media control. The layout of the report is shown in **Figure 3**. I only needed to control the volume and mute functions for this project but if you want to experiment with the software provided, you can change the source code to control the other usages.

The media usages function likes push on/push off buttons. For example, to toggle mute on, the device's firmware needs to send a "1" in bit location 0 to the host. The device must then send a "0" in that bit position to reset the toggle because the usages are triggered on the 0 to 1 transition.

When the device is plugged into a USB port, it receives power, resets, and runs through its initialization routine. The device then connects an internal resistor (1.5 KW) from the D+ line to the internal 3.3V regulator, creating a voltage change on the D+ line. This lets the host know that a full speed device has attached and causes a sequence of events to occur called enumeration. During enumeration, the host reads the contents of the descriptor. Once enumeration is complete, the device is configured and ready to send data to the host. To move data, the USB standards specify that HID devices use the Interrupt Transfer protocol.

INTERRUPT TRANSFERS

All USB devices operate on the same basic principle: The host makes a request for data and the device responds. So, how does the device signal the host when it has data available? The type of data transfer used by HID devices is called an interrupt transfer, but this is misleading. There is no mechanism for the device to call the host when it has data ready. To receive reports from the device, the host makes periodic requests for data — in our device, every 10 milliseconds — called a "polling interval." When the device has data ready to send to the host, the device loads its data into a special memory location called an endpoint. During each polling interval, the host asks the device to send the data in the endpoint. If the device has no data to send, it responds with a Zero Length Packet (ZLP) instead.

To update a media control, the device firmware must read the encoder/pushbutton, set the correct bit in the report, and wait for the host to poll that information. Before the main program can reliably use the pushbutton and encoder values, the inputs need to be cleaned up.

CONTACT BOUNCE

Mechanical switches require contact debouncing to prevent false signals. **Figure 4** shows an example oscilloscope capture of what the microcontroller sees when the mute button is pressed. The encoder switches have a similar contact bounce characteristic. The strategy is to wait until the switch has stabilized after the first closure has been detected, and I decided to implement debouncing in software. A hardware solution was possible but would have meant more components.

Debouncing is handled using one of the AT90USB162's built-in timers to sample the switch input pins periodically. The encoder and the mute pushbutton require separate debouncing algorithms due to their different characteristics. Debouncing the pushbutton is simple. A software routine uses an eight-bit shift register to accumulate a sample from the

PARTS LIST

PART ID	NAME	PACKAGE	Digi-Key PART#
R1	470 ohm, 1%	0806	RC0805FR-07470RL
R2,R3	22.0 ohm, 1%	0806	RC0805FR-0722RL
C1,C4	0.1 µF/16V	0806	GRM219R71C104KA01D
C2,C3	18 pF/50V	0806	500R15N180JV4T
C5	1.0 µF/16V	0806	TCP1C105M8R
C6	10 µF/16V	Through-hole	199D106X9016C6V1E3
U1	AT90USB162	32 TQFP	AT90USB162-16AU
Y1	16 MHz crystal	49US	ECS-160-20-4VX
D1	LED hi eff blue	3 mm	TLHB4400
S1/S3a/S3b	Encoder with switch	Panel mount	288V232R161B2
S2	Reset	Tactile	EG1829
Box	Enclosure	Aluminum	1590LLB
Knob	Knob for encoder	Aluminum	450-1712-ND
Cable	USB cable	Round, 3'	3021005-03

switch input every millisecond. A steady run of seven zeroes following the last bounce reliably signals the button has been clicked.

The encoder is more complex because it has two pins to work with at the same time, and either the on or off states may be valid. Every millisecond, a counter is incremented for a stable sample (i.e., the current value equals the previous value). Otherwise, it is decremented. This acts like a capacitor filtering out any contact bouncing. Once a number of stable samples have been achieved, the direction of rotation can be determined. I found the best compromise between responsiveness of the encoder and reliable sampling by experimenting.

■ **FIGURE 5.**

Forward → ← Reverse

	Direction (A XOR B')		1	1	1	1		0	0	0	0	
Denotes Encoder switch closure to common	Previous B (B')		0	0	1	1		0	1	1	0	
	Current B	0	0	1	1	0		0	0	1	1	0
	Current A	0	1	1	0	0		0	1	1	0	0
	Position No.	1	2	3	4	5	...	13	14	15	16	17

Truth Table Exclusive Or (XOR)

A	B	XOR
0	0	0
0	1	1
1	0	1
1	1	0

UsbHid.c External Functions	
Function	**Purpose**
Usb_Init()	Initialize the USB module.
Usb_Open()	Attach internal 1.5K resistor to the D+ signal line.
Usb_WriteEndpoint(byte)	Write a byte to the Endpoint followed by a write of 0x00 to reset the Usages (see text).
Usb_IsConfigured()	Check to see if the device is configured and ready.
Usb_IsSuspended()	Check to see if the Host has requested the device to enter low power mode.

■ **FIGURE 6.** Just five library functions provide all of the USB interaction required by the main program.

ENCODER DIRECTION DECODING

The type of encoder specified in the **Parts List** is an incremental encoder and requires some logic to figure out if you are turning it clockwise or counterclockwise. Direction is determined by "exclusive or-ing" the encoder's previous most significant bit with the current least significant bit. **Figure 5** shows the sequence generated by the encoder in either direction.

To ensure the encoder logic reports the correct direction after initial device reset, the previous encoder value is initialized to the current port value during device initialization.

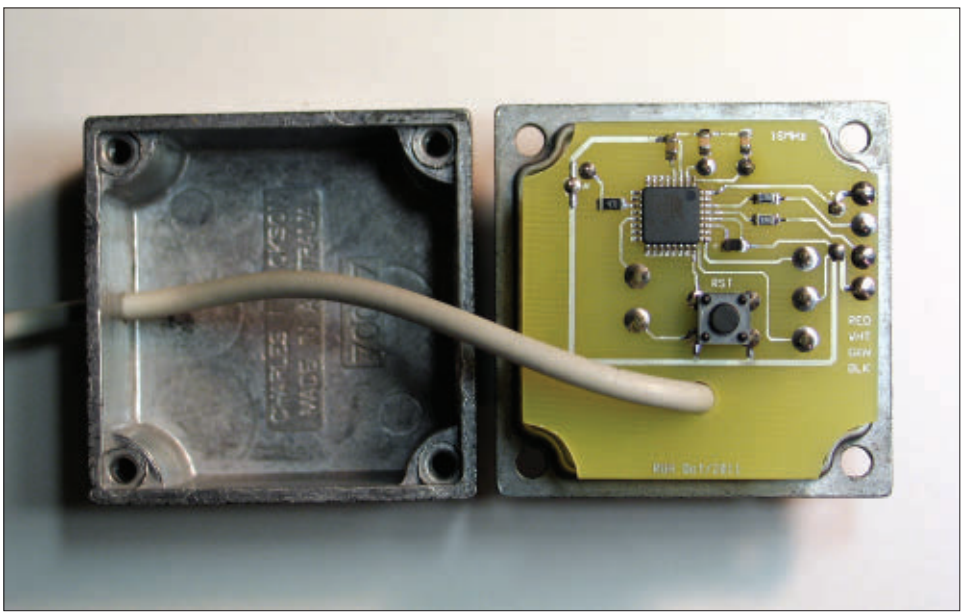
SOFTWARE

The software provided includes all of the functions needed to manage the HID protocol and switch interfacing. The module UsbHid.c exposes all of the functions needed to manage the USB interface and are summarized in **Figure 6**. The source code supplied with this article shows how to use the library.

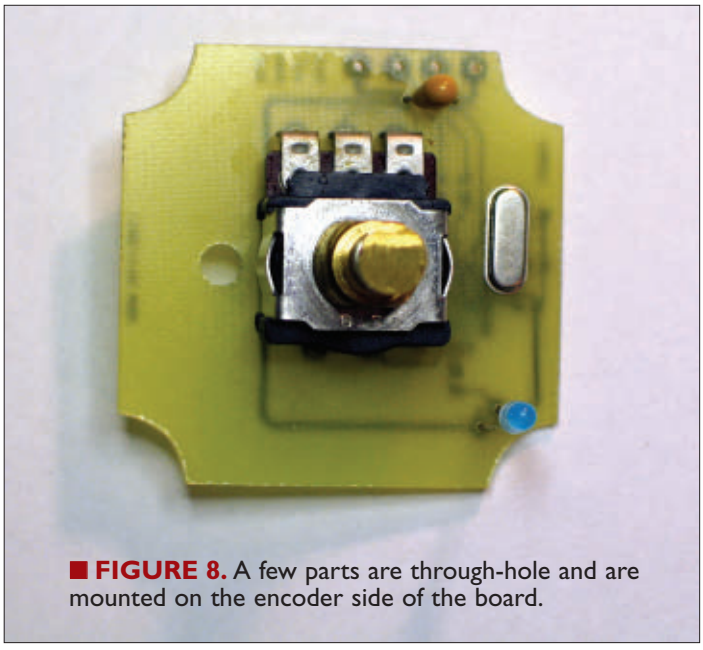
Once the USB module has been initialized, the main loop waits for the device to be configured, at which point the host begins regularly polling the device's endpoint. When the Windows host goes into stand-by, a USB signal is sent to the device to tell it to go into low power suspend mode. When the device detects this state, the device turns off the configured LED and executes the sleep instruction to halt the CPU. Power consumption in this state is less than 0.5 milliamps. When the host resumes, the device automatically wakes up and becomes operational.

CONSTRUCTION

The AT90USB162 does not come in a standard



■ **FIGURE 7.** Inside view. The cable feeds through a hole in the PCB to act as a strain relief for the cable.

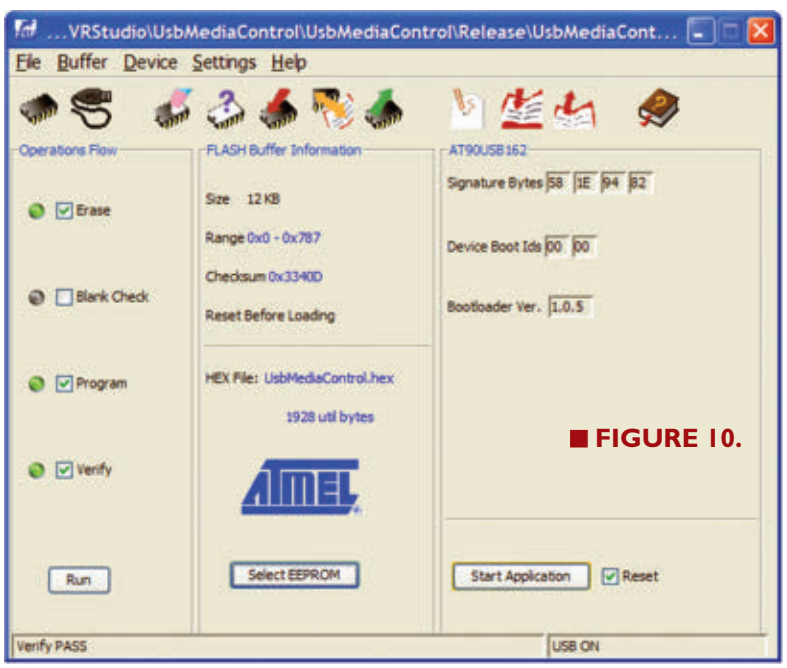


■ **FIGURE 8.** A few parts are through-hole and are mounted on the encoder side of the board.

■ **FIGURE 9.**

experimenter-friendly Dual In-Line (DIP) package. It is only available as a surface-mount device (SMD). SMD components are surprisingly easy to work with, and this package form should not deter you from building this project. An excellent tutorial on SMD soldering can be found at **www.eevblog.com**, episode #186. (Warning: Try not to get too distracted by all the other interesting electronics videos on Dave's site until you have finished this project.)

I was able to make a single-sided PCB using the Press 'n Peel Toner Transfer system for the prototype. Due to its simplicity, the device could easily be constructed using perf-board techniques. **Figure 7** and **Figure 8** show how I used the box described in the **Parts List** to build the prototype.



■ **FIGURE 10.**

Begin assembly by soldering the AT90USB162 chip (make sure pin 1 is correctly oriented before soldering). Next, solder the SMD resistors and capacitors, crystal, encoder, reset pushbutton, and status LED.

Finally, feed the USB cable through a hole in the side of the box and then through the hole in the PCB that acts as a cable strain relief. Solder the cable wires to the board making sure that the color coded wires attach to the correct pads. Soldering mistakes or shorts could damage your USB port. I used a cable salvaged from an old USB mouse, but you can purchase an open ended cable for this purpose (see **Parts List**). Don't close up the box just yet. You will need to access the reset pushbutton to program the device.

PROGRAMMING

Download the project files from the article link. Save the files on your hard drive in a folder called UsbMediaControl. Next, install the software to program the device. To do this, download and install the FLIP software from Atmel's website (**www.atmel.com**). I recommend that you install the version that includes the Java runtime to avoid any compatibility issues.

Once FLIP is successfully installed, attach the device's USB cable to a USB port on your computer and place the device in DFU mode by performing this sequence:

1. Press and hold the reset button.
2. Press and hold the mute button

(i.e., press down on the encoder shaft).
3. Release the reset button.
4. Release the mute button.

If everything is going according to plan, your computer will load the DFU driver. You can confirm this by looking at Device Manager — you should see LibUSB-Win32 Devices entry in the list (see **Figure 9**).

Start FLIP and load the object file from the project files you downloaded earlier. Here are the steps:

1. Click on **File -> Load Hex File**. Navigate to the ***Release*** folder in the UsbMediaControl directory where you saved the project files and double-click on UsbMediaControl.hex.
2. Click on **Device -> Select -> AT90USB162** to select the correct device.
3. Click on the USB connector icon on the menu, then select **USB** from the pop-up and click on **Open** when prompted.

The FLIP control panel will look like **Figure 10** at this point. To load the firmware into the device, complete the following steps:

1. Click on **Run**. The firmware will load and the dots next to Erase, Program, and Verify should all turn green if everything is okay.
2. Click on **Start Application**. The blue configured LED on the device should light indicating the device is programmed, configured, and operational.

Try turning the encoder and operating the mute pushbutton (press down on the encoder dial) to confirm the device is working properly.

Atmel "FLIP" DFU bootloader installer and AVR Studio 5
www.atmel.com

FINAL NOTES

The source code has been included so that you can experiment with different configurations. You can download Atmel's (free) Studio 5 development environment that includes a C compiler and code editor. One thing to note is that you will have to change the Solution Configuration from "Debug" to "Release" to ensure the compiler is operating in optimized mode. This object code won't run properly in the (default) non-optimized mode. **NV**

The Radio Whisperer

A unique circuit, a few feet of wire, and some powerful software combine to make an amazing communications tool capable of spanning the world.

By George Steber

www.nutsvolts.com/index.php?/magazine/article/january2012_Steber
Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

Advances in communications in recent years have come at a startling pace. In the old days, to communicate via radio one needed a good antenna, a selective receiver, and a powerful transmitter. While those items are still useful, today there is one more item required: good software. The "weak signal propagation reporter" software or WSPR (pronounced "whisper") is one such advanced methodology. WSPR will astound you with its ability to communicate globally using very low power with received signals at or near the noise threshold. We are talking (in this context) about transmitting power levels of 500 milliwatts (mW) and often much less. One of my WSPR signals was received 1,600 Km away from my home while I was using only 10 mW of transmitter power and a short 24 foot length of wire. Low power WSPR signals were received on the same piece of wire from over 6,000 Km away.

If you are interested in learning more about this technology and how you can participate by building your own low cost WSPR receiver, keep reading. We will cover all of that and more. Before we get to that, let's talk about a special application. If you are an educator or know someone involved in teaching science, please take note. WSPR is not only for electronics experimenters, but can be used to help teachers motivate their students in science while presenting relevant technical methodology. Motivation will likely occur because WSPR encompasses a wide range of subjects such as electronics, communications, Internet, software, physics, geography, and more.

Philosophically speaking, modern scientific methodology is something we learn, not something we are born knowing. We have an inherent, untapped capacity to explore and comprehend the world around us. Curiosity is at the root of science. The question, "How does that work?" is key to that curiosity. Indeed this path has been followed from Ptolemy to Einstein to Hubble.

In the classroom, a WSPR receiver is simply connected to a wire antenna and a PC or MAC. As it runs, stations from around the globe (on certain bands) may be received. It is different than hearing commercial shortwave broadcasting because you are receiving data of a scientific nature. This is an exciting, motivating phase for the kids. They will want to know how it works. So, don't be surprised if some of them ask to borrow the receiver to take home to use on their own.

A particularly nice feature of

FIGURE 1. World map from WSPRnet.org.

WSPR is that "receptions" (called spots) can be automatically downloaded to a central database (**WSPRnet.org**) with results shown on a large map of the world (see **Figure 1**). A flag will appear on the map to show your location and which stations you have received. Hence, exact transmitter locations can be determined and distances, headings, and other information reported. The world map can be zoomed to learn more about the geography and radio path found. Particularly thrilling for younger children is this reporting phase as they feel a sense of participation.

More details about this project (including how to obtain ready-to-go WSPR receivers, lesson plans for teachers, and more) are available at **http://stellarwspr.com**. WSPR signals are in the amateur radio part of the spectrum and transmitters will require a license in most jurisdictions. Happily, many WSPR transmitters are now operating around the globe to provide interesting "catches" for the kids.

Why Do We Need WSPR?

We know from our high school physics class that when a transmitter signal moves down a wire to an antenna that part of it is launched into space as an electromagnetic (EM) wave. This energy propagates through space in various directions dependent on many factors, like the antenna size and orientation. All kinds of things can happen to the signal after it is launched. It can be refracted and polarized, for example. For communication, another antenna some distance away from the transmitter can intercept part of the signal and receive a message if one is contained in the signal. For example, Morse code is sent by turning the signal on and off (modulating it). Of course, for modern radio communications more advanced modulation methods are used. In an ideal universe, the EM wave would propagate forever and still be able to be demodulated perfectly at almost any distance with just the tiniest amount of signal available. However, in our real world there is another factor. In addition to the things mentioned above, we need to consider the ramifications of electrical noise.

As the EM wave propagates, it spreads out in space and therefore diminishes in strength in any given direction. Simply stated, it gets weaker. To add to the problem, the ionosphere — which carries much of the high frequency signals — also is continuously changing, causing propagation variations like fading. Noise, on the other hand, is all around our real universe being generated from all kinds of things like appliances, radar, and natural phenomenon like lightning. The noise level continuously fluctuates and causes interference to our signal.

To partially deal with the noise and also to provide additional features, various modulation techniques have been developed. Two classic ones you are probably familiar with are AM (amplitude modulation) and FM (frequency modulation). Some modulation methods are better than others at dealing with noise, but they all get into trouble when the signal strength approaches the noise level.

Band	Dial Freq. (MHz)	Transmit Freq. (MHz)
160m	1.836600	1.838100
80m	3.592600	3.594100
60m	5.287200	5.288700
40m	7.038600	7.040100
30m	10.138700	10.140200
20m	14.095600	14.097100
17m	18.104600	18.106100
15m	21.094600	21.096100
12m	24.924600	24.926100
10m	28.124600	28,126100
6m	50.293000	50.294500
2m	144.488500	144.490000

FIGURE 2. WSPR radio bands; center frequencies, bandwidth 200 Hz.

What makes WSPR different? It's the *protocol*. WSPR software utilizes an extremely narrow frequency band with specially-coded forward error correcting (FEC) and frequency shift keying (FSK). FSK is like very narrow band FM. This technique reduces errors and improves the possibility of copying the message in noise. The signal fits into a tiny 200 Hz segment. Within each segment, the signal bandwidth is only 6 Hz. This allows several tens of stations to coexist in a segment with minimal interference. There are 12 segments presently (denoted here as the WSPR bands), located within the radio frequency spectrum (see **Figure 2**).

The WSPR protocol is extremely effective at signal-to-noise ratios as low as –28 dB in a 2,500 Hz bandwidth. This is over 10 dB below the threshold of audibility. In other words, you can sometimes copy signals that you cannot hear. It is because of this capability that even low power WSPR signals can be decoded in the farthest reaches of the globe.

WSPR Acknowledgement and Usage

WSPR was conceived and put into operation by Joe Taylor (K1JT), an amateur radio operator (Professor of Physics at Princeton) and fellow amateur Bruce Walker

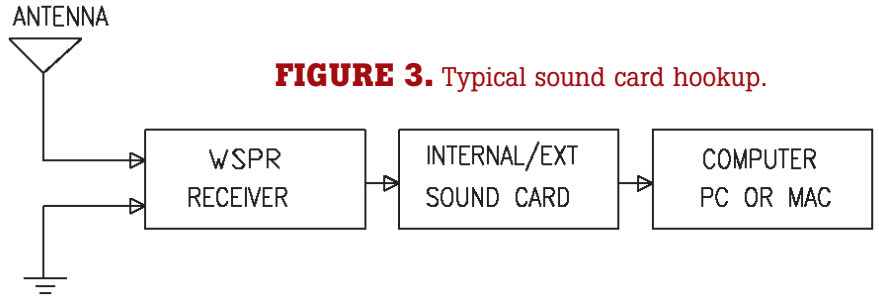


FIGURE 3. Typical sound card hookup.

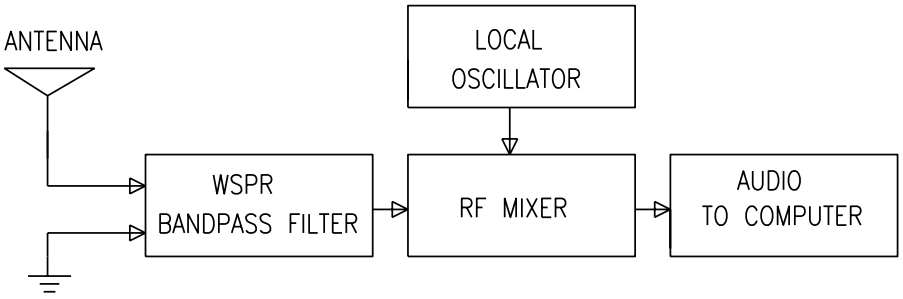


FIGURE 4. Block diagram for the WSPR receiver.

(W1BW). The open source software runs on Windows, Linux, and other systems. It is available from **www.physics.princeton.edu/pulsar/K1JT** as a free download.

WSPR utilizes the internal or external sound card of your PC/MAC (see **Figure 3**). These cards have good specifications. Foremost are the data converters providing a large 90 dB dynamic range which is used to the fullest. WSPR is programmed to send and receive messages through the card. Here's more about WSPR protocol.

WSPR uses time-synchronized communications based on Coordinated Universal Time (UTC). Transmissions last somewhat less than two minutes each, nominally starting one second into an even UTC minute. Hence, it is important for your computer to be accurate to within a second or so of UTC. So, set your computer clock to an accurate source such as **www.usno.navy.mil**.

Since most computer clocks drift, you will need to update your clock periodically.

WSPR is designed to do just one thing: find a communication path. It communicates via specially formatted messages aimed at determining if a propagation path is open on a given transmitting frequency. Formatting contains a name, four character grid locator, and power level in dBm (decibels relative to one milliwatt). This information is compressed into 50 binary digits and encoded using a convolutional code of length 32 and rate 1/2. The resulting 162 bits are transmitted using four tone FSK at 1.46 baud. The least significant bit is defined by a pseudo-random sequence known by the software at *both* transmitter and receiver. It is used to establish accurate time and frequency synchronization. Long convolutional codes are advantageous since undetected decoding errors are rare. Normally, a Viterbi algorithm is used for decoding but due to complexity, the WSPR decoder uses a special sequential algorithm.

When a station is decoded, other information such as "receive location," name, S/N ratio, and DT (time difference) is routinely logged. This information can be automatically downloaded to **WSPRnet.org** using the "spots" option. Your name will then be shown on a flag on a world map with others. Options on the website can be used to find the distance and direction of the station received.

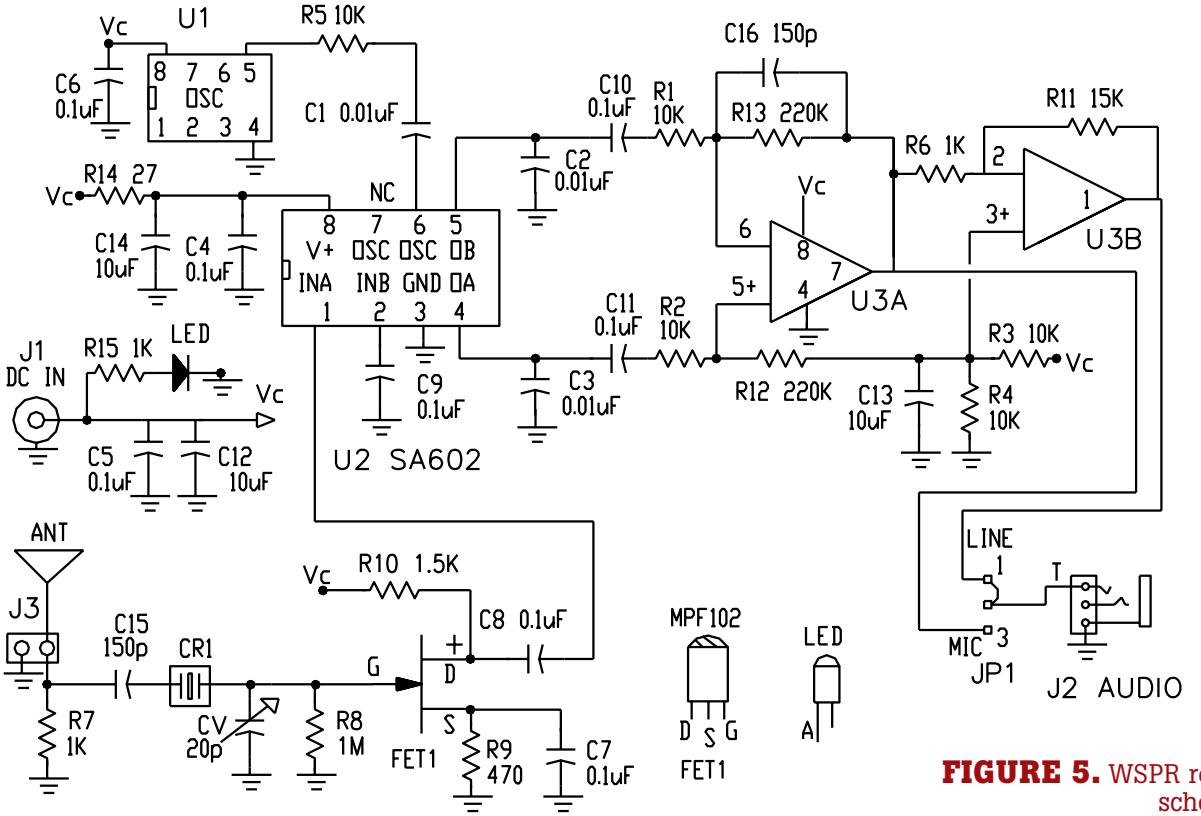


FIGURE 5. WSPR receiver schematic.

WSPR Receiver

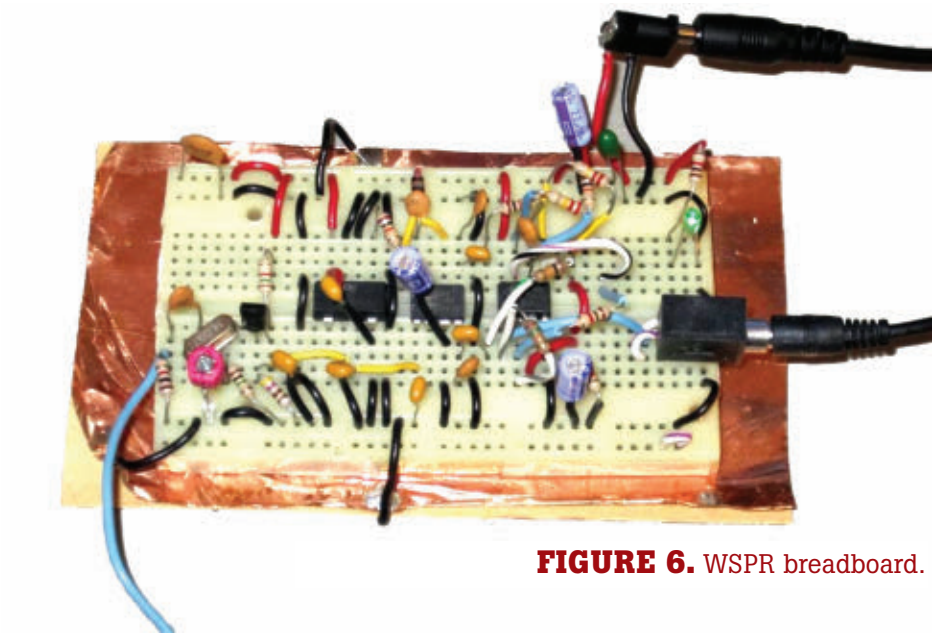


FIGURE 6. WSPR breadboard.

What do we need to receive WSPR signals? First, realize that WSPR is transmitted as a single-side band (SSB) signal so it cannot be received with an ordinary AM receiver. Some shortwave radios have a BFO (beat frequency oscillator) and could be used if they possessed sufficient accuracy and stability. Also since the signal is in a very narrow band and almost inaudible, manual tuning would be difficult. Ham band receivers are another option, but more costly. So, it appears that finding a low cost WSPR receiver can be problematical. Is there another approach? Yes! Let's design our own unique WSPR receiver from the ground up. On the hardware side, we need to build a WSPR receiver with high accuracy, stability, and sensitivity at low cost. In addition, it should not require complicated alignment or adjustment procedures involving special equipment. Quite a task.

Recall that the function of the receiver is to convert the WSPR radio signals to audio for the computer sound card. A good candidate for these requirements would be some type of fixed, direct conversion (DC) radio. DC receivers convert radio signals to audio directly without any intermediate stages. A block diagram of the proposed radio is shown in **Figure 4**. Here is how it works.

RF signals from the antenna are bandpass filtered at the WSPR *receive* frequency to prevent overloading the mixer from strong out-of-band signals. A local oscillator (LO) tuned to the WSPR *transmit* frequency is mixed with the RF. Since the two frequencies are separated by 1,500 Hz, audio centered at 1,500 Hz is produced at the output of the mixer. Finally, this audio is fed to the computer sound card. WSPR software has a 200 Hz bandpass centered on 1,500 Hz with narrow digital filters. So, if we get the audio to the sound card there is a good chance it will be decoded. Implementing the block diagram requires some unique thinking. First, we do not want an adjustable LO as this would require special equipment. Also, we do not want special coils that need to be tuned because measuring these would be difficult for many hobbyists. **Figure 5** shows the circuit conceived. It functions like the block diagram.

Two changes need more explanation. First, the LO is replaced with a programmed oscillator. This removes the need to adjust an oscillator. Programmable oscillators are essentially custom programmed crystal oscillators. Secondly, the input bandpass filter is now a crystal tuned to the WSPR frequency. Crystals provide a narrow band-pass function without using conventional tuned circuits. However, special crystal frequencies are required. Crystals for the 20 and 30 meter WSPR bands will be available as noted later. Here is a description of the circuit in **Figure 5**. From the antenna, the signal is passed through the crystal filter to a FET amplifier. Next, it is fed to one input (pin 1) of U2 — the SA612 mixer. The SA612 functions well in this application since it has gain (unlike passive mixers) and is protected from out-of-band signals by the crystal filter. Programmable oscillator U1 — programmed to a specific WSPR transmit frequency — feeds pin 6 of the mixer. The result is a differential audio signal on pins 4 and 5 of the mixer. This signal is further processed by U3 and presented to the sound card via JP1 and J2. Select the "line" or "microphone" jumper for your computer sound card.

The crystal filter may need peaking via the 20 pF variable capacitor CV. Since this is a sensitive place in the circuit, use care to avoid false readings. Adjust for maximum audio at 1,500 Hz. One way is to look at the audio spectrum with a free program like "Spectrum Lab," from **www.qsl.net/dl4yhf**. A better method of alignment is to receive a nearby signal generator set to the WSPR receive frequency. Adjust CV for maximum while viewing the 1,500 Hz audio spectrum peak.

The circuit is powered by five volts through an AC to DC wall mount converter. Such converters can be troublesome. Check its voltage under load before using. Exceeding 5.5 volts may damage some parts. Using a computer USB port may work. We had good experience powering from the USB ports of some older laptops, but experience with other computers has produced strong interference from the USB port. In these cases, use the five volt wall mount converter.

For demonstration purposes, a breadboard of the 20 m receiver was built on a circuit strip shown in **Figure 6**. This technique, generally speaking, is not a good method for RF circuits but it worked here. A PCB is a better option and will be available also noted later.

Figure 7 gives the **Parts List** for the project. Most

QTY	LABEL-VALUE	DESIGNATION(S)	DESCRIPTION
8	0.1 µF	C4, C5, C6, C7, C8, C9, C10, C11,	Mono capacitor
3	10 µF	C12, C13, C14	Electrolytic
2	150 pF	C15, C16	Ceramic disc
3	0.01 µF	C1, C2, C3	Ceramic disc
1	15K	R11	1/4W 5%
3	1K	R15, R6, R7	1/4W 5%
1	1.5K	R10	1/4W 5%
1	27	R14	1/4W 5%
5	10K	R1, R2, R3, R4, R5	1/4W 5%
1	470	R9	1/4W 5%
1	1M	R8	1/4W 5%
2	220K	R12, R13	1/4W 5%
1	3SIP	JP1	SIP3
1	MPF102	FET1	FET
1	LED	GREEN	LED
1	20p	CV	VAR C
1	J1	DC	JACK 3.5 mm
1	J2	AUDIO	3.5 mm stereo
1	J3	ANT	Two terminal
1	U2	SA612	RF mixer
1	U3	TLC272	Dual op-amp
1	U1	Programmable OSC	WSPR transmit freq
1	CR1	Crystal	WSPR receive freq

FIGURE 7. Receiver Parts List.

parts for the receiver are readily available. Programmable oscillators are available from Digi-Key and others as a custom order. You need to specify the package (usually eight-pin DIP) and frequency. Some special crystals are available on the Internet. A PCB and most of the critical parts such as crystals and programmable oscillators for the 20 and 30 meter bands will be available on eBay, including ready-to-go receivers. Search for WSPR. Also check **http://stellarwspr.com** for the latest information on this project.

WSPR Software and Receiver Operation

Using the WSPR software is easy. To get started, download and run the software from **www.physics.princeton edu/pulsar/K1JT/**. Two windows will appear on your screen. The black one is for error messages. **Figure 8** shows the main window. To check operation, you can play back an audio sample included with the program. If you want to check out actual band activity, use **WSPRnet.org** for current spots.

Assuming you have a receiver, connect it to a good antenna and the audio output to your sound card. A long antenna high in the air working against a good ground works best, but even a random length wire works. If possible, try to make your antenna one-quarter wave long as it will better match the input. For example, on the 30 meter band make the wire 7.5 meters long (24.6 feet). It cannot be over stressed that a good ground helps enormously. Even a long ground wire on the floor helps. Keep the antenna away from the computer. Using a short

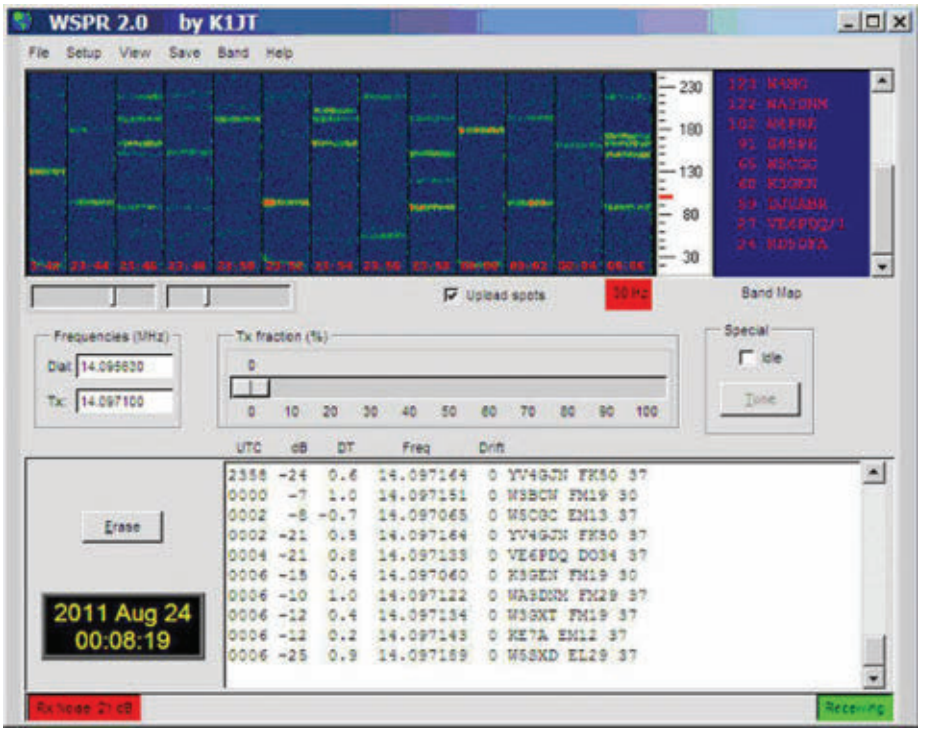


FIGURE 8. WSPR operating window.

coax cable may help.

Now, set your computer clock to UTC within one second or so. Correct UTC can be found on the Web. We use the Naval observatory at **www.usno.navy.mil**. Now comes the anxious part. You need to wait for an *even* numbered minute (0, 2, 4, etc.) for the software to begin receiving. Watch your computer clock. At this point, the message in the lower *right* corner will change from "waiting" to "receiving." The lower *left* corner will specify the level of the input audio in dB. This can be adjusted with your sound card recording level control.

A level of 12 to 19 dB works well, even though the software says otherwise and produces a red window. There are a few other things you can do, like putting in your grid location and call (or name) if you want to report your spots. But that will come later. For now, sit back and watch for your first catch.

Final Comments

WSPR is amazing technology. The simplicity of the WSPR receiver described here makes it attractive as a low cost radio propagation tool. With a bit of luck, it will motivate experimenters, teachers, and students to begin exploring the many facets of science and engineering touched upon here.

As stated, the question, "How does that work?" is indeed the key to curiosity. Hopefully, it will help the young stay interested in science.

This receiver is only the first step. Other projects involving more sophisticated receivers and transmitters will surely follow. There was recently an article "Chips In Space" by Mason Peck (*IEEE Spectrum* August '11) which described how satellites the size of small integrated circuits could revolutionize the way we explore space. Project Sprite involves designing and later on launching many thousands of low mass chips (under 50 milligrams) for the single purpose of monitoring space with simple sensors. Each chip will have a weak radio transmitter and signal barely discernable from noise. Sophisticated signal processing software will be needed to pull the signals out of the noise.

Perhaps a youngster intrigued by WSPR will be the future engineer to design that software. **NV**

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FUNDAMENTALS FOR THE BEGINNER

Build a Variable Timer

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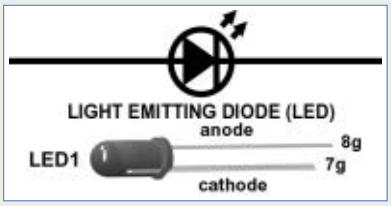
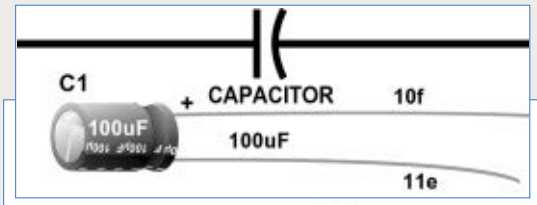
This is an adjustable timer circuit. The time that the output pulse is HIGH on pin 3 of the 555 timer IC is controlled by the potentiometer setting.

Build the Circuit. Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

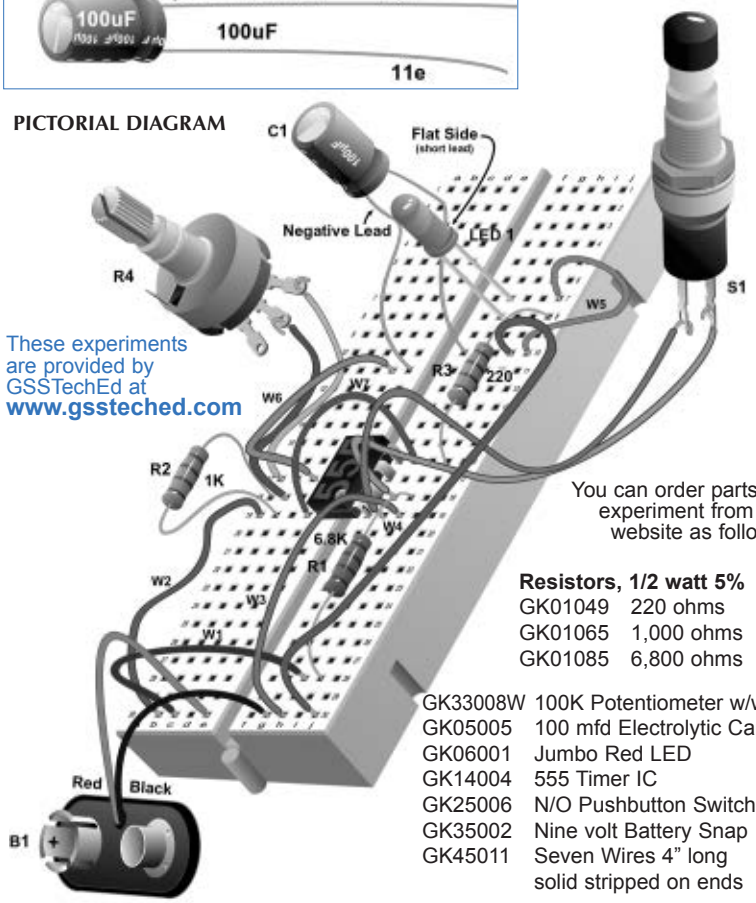
Do the Experiment. **Theory:** This is a 555 timer IC set up as a monostable multivibrator, or timer. Monostable refers to the idea that the output stays at LOW until triggered to go HIGH. Once triggered, it remains HIGH for a period of time and then returns to LOW. The duration of the HIGH on pin 3 depends on the values of R2, R4, and C1. The potentiometer needs to be set in the full clockwise position to start. When you press pushbutton S1, you put a LOW (a negative) on pin 2. This 'triggers' the timer. It now puts out a HIGH on pin 3 for a period of time, depending on how you have adjusted the potentiometer. Capacitor C1 can be replaced with larger values in order to get longer periods of time.

Procedure: Connect a nine volt battery to the battery snap. Press and release S1 and observe that the red LED is lit for a period of time and then shuts off by itself.





PICTORIAL DIAGRAM



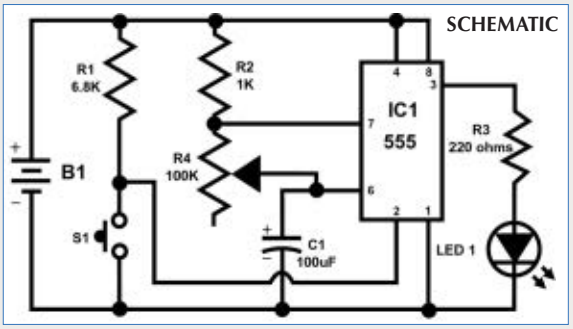
These experiments are provided by GSSTechEd at www.gssteched.com

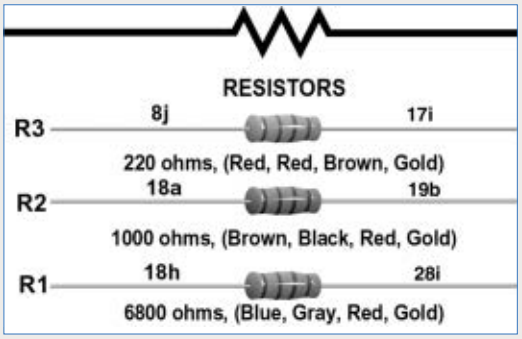
You can order parts for this experiment from their website as follows:

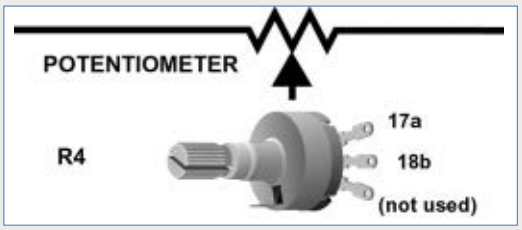
Resistors, 1/2 watt 5%
GK01049 220 ohms
GK01065 1,000 ohms
GK01085 6,800 ohms

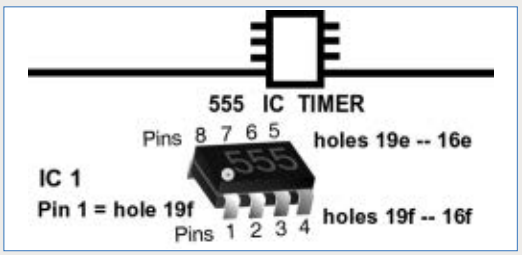
GK33008W 100K Potentiometer w/wires
GK05005 100 mfd Electrolytic Capacitor
GK06001 Jumbo Red LED
GK14004 555 Timer IC
GK25006 N/O Pushbutton Switch w/wires
GK35002 Nine volt Battery Snap
GK45011 Seven Wires 4" long solid stripped on ends

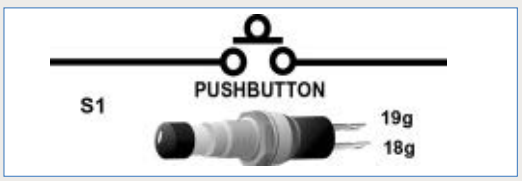
SCHEMATIC



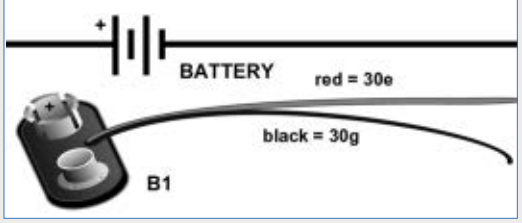








WIRES
W1 = 30c and 28h
W2 = 19a and 30b
W3 = 19h and 30h
W4 = 10i and 30j
W5 = 7j and 10j
W6 = 11d and 17d
W7 = 16g and 19d



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#42 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

Breadboard LCD Navigator — Part 1: the LCD

Follow along with this series! Joe's book & kits are available at www.nutsvolts.com

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

Recap

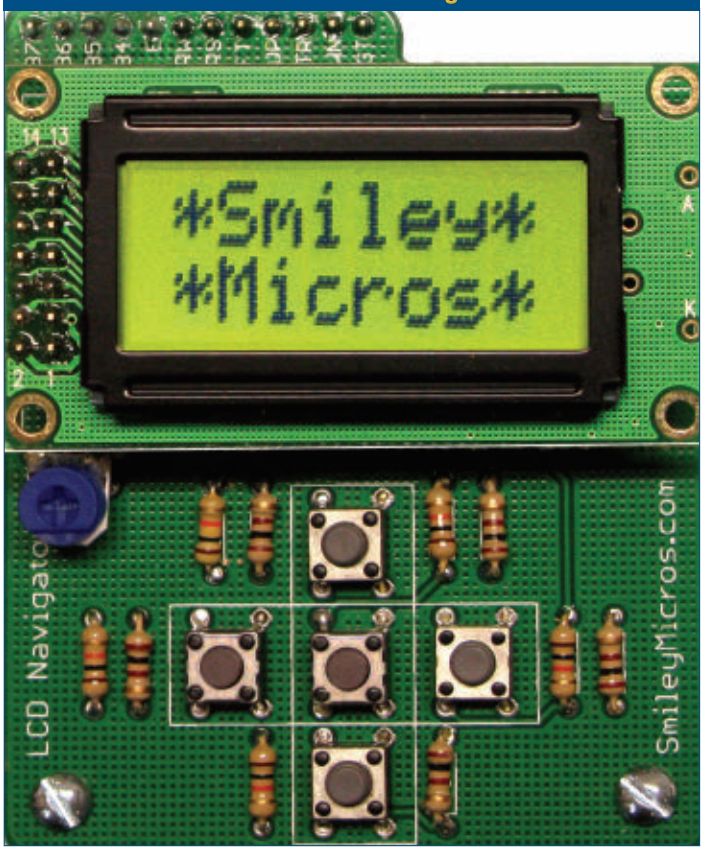
Over the past several months, we looked at Digital I/O (DIO). In Part 1 (October '11), we looked at the software side of DIO as it is done in the Arduino using sequentially numbered pins on the Arduino board. We wrote a library of functions similar to the Arduino DIO library functions but used regular C concepts and tools (AVRStudio, WinAVR, avrdude, avrlibc, etc.).

In Part 2 (November '11), we saw that the Arduino pins are simple abstractions of the deeper AVR microcontrollers' concept of ports that are eight-bit arrays of pins. We wrote a library that specifically handles ports and their pins as they are used by raw AVRs.

Last month, we dropped the abstractions and looked at how DIO is really done in AVRs using the tools available in C, without having to write special libraries to manipulate the ports and pins for DIO. We also went deep into bitwise operators — a painful but necessary bit of learning that is required if you really want to know what C programming is all about (and microcontrollers in general, for that matter). We applied all that to a simple chaser light application that you can find at: **http://code.google.com/p/avrtoolbox**. You can test it in hardware with the BreadboArduino Projects kit available from the *Nuts & Volts* webstore.

We are now going to have some fun and apply what we've learned about DIO by building something really useful: an open source project that has an LCD and five buttons used to navigate through menus shown on the LCD. You can think of this as a tiny computer terminal and keyboard; a very minimalist (read cheap) one for the AVR. Like other Smiley's Workshop projects, you can get the parts kit from the *Nuts & Volts* webstore, as well.

■ FIGURE 1. LCD Navigator.



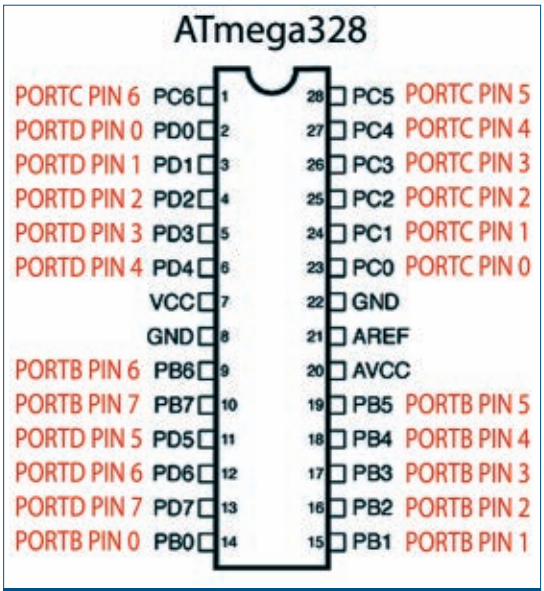
Theory Section: Digital I/O in C

The C programming language knows nothing about AVR DIO. C is a hardware independent programming language and runs on any computer. The AVR is a specific computer that does the same sorts of things that are done by other microcontrollers (such as the 8051 or PIC), but it does those things using different hardware. C abstracts the sorts of things you can do with a computer into a higher-level concept that mimics a generic computer. C leaves it up to the compiler to convert the C code into the actual

assembly language instructions that a particular computer uses.

C does such a good job of abstracting the way computers work that it is often called a generic assembly language. In early October '11, *Wired Magazine* posted a eulogy to Dennis Ritchie, the father of C:

Ritchie's running joke was that C had "the power of assembly language and the convenience of ... assembly language." In other words, he acknowledged that C was a less-than-gorgeous creation that still ran very close to the hardware. Today, it's considered a low-level language, not high. But Ritchie's joke didn't quite do justice to the new language. In offering true data structures, it operated at a level that was just high enough.


ATmega328
PORTC PIN 6 PC6 1
PORTD PIN 0 PD0 2
PORTD PIN 1 PD1 3
PORTD PIN 2 PD2 4
PORTD PIN 3 PD3 5
PORTD PIN 4 PD4 6
VCC 7
GND 8
PORTB PIN 6 PB6 9
PORTB PIN 7 PB7 10
PORTD PIN 5 PD5 11
PORTD PIN 6 PD6 12
PORTD PIN 7 PD7 13
PORTB PIN 0 PB0 14
28 PC5 PORTC PIN 5
27 PC4 PORTC PIN 4
26 PC3 PORTC PIN 3
25 PC2 PORTC PIN 2
24 PC1 PORTC PIN 1
23 PC0 PORTC PIN 0
22 GND
21 AREF
20 AVCC
19 PB5 PORTB PIN 5
18 PB4 PORTB PIN 4
17 PB3 PORTB PIN 3
16 PB2 PORTB PIN 2
15 PB1 PORTB PIN 1

■ FIGURE 2. ATmega328 port pin mapping.

Our job is to take the generic things that C can do and use them with the specific things that our AVR can do. Herein lies the rub. AVRs can do a LOT, and as I've said before, one of the biggest problems with these things is that they can do so many different things in so many different ways, that it is a chore to figure out which of these many is 'best' for a given application. The datasheets are the ultimate resource. Unfortunately, they tell you how to do everything, but don't give much of a hint as to which things you should choose as the best way to do the task at hand. If you haven't already done so, I recommend that you get the datasheet for the ATmega328 from **www.Atmel.com** and skim through it – especially the Digital I/O section. What you'll notice is that the datasheet offers so much bounty that it is nigh impossible to sort out what we really need to do to get these pins inputting and outputting. Let's take the bitwise stuff we learned last month and see how that is used to set up the DIO registers.

AVR Registers

The AVR uses eight-bit memory locations called registers to set the functionality of each of its peripheral devices. We've sort of hit at AVR registers in other Workshops, but let's take them on again; this time from the perspective of how we will use them with C and bitwise operators.

Register space is located near the beginning of the AVR memory space. There are a total of 86 registers listed for the ATmega328. They sport names like SPCR, TCNT0, EEARH, EIFR, TIFR2, and so forth. Many of these registers have bits that you set or clear to activate or deactivate a specific AVR function. These bits also have names like TWAM6, COM2B1, ADIE, PCINT22, SP2, ACBG, and so forth. The point I'm making here is that there are hundreds of acronyms used to control the various AVR functions, and neither you nor I have a chance in heck of remembering even a small fraction of them. Thus, it is a painful necessity to get intimate with the datasheet. This pain can be somewhat alleviated by using the Atmel Application notes, forums like **www.avrfreaks.net**, and tutorials like this one, but ultimately if you are going to get proficient with microcontrollers you have to get real friendly with datasheets.

AVR I/O-Port Registers

If you refer to the I/O-Ports section of the datasheet and look at the Register Description, you'll see 10 registers listed. We are interested in nine of these registers that are used to control Ports B, C, and D. Each port has a PORTx data register, a DDRx data direction register, and a PINx port input pin address register. The bits of each of these registers maps directly to the external I/O pin on the device as shown in **Figure 2**. The PORTx register is used primarily to write data to these pins, the PINx register to read the external state of the pin, and the DDRx to set the direction of the pin. [We discussed the electrical aspects of I/O pins in Part 1 of the DIO series.]

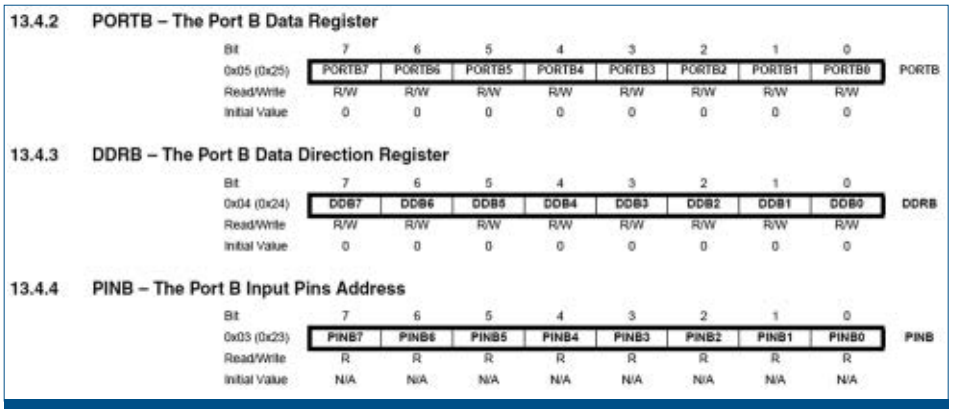
Figure 3 shows these registers in the datasheet; you can see that the individual bits in the registers are logically named after the external pin they represent. Just a note of warning: The PINx register is eight bits just like the PORTx register and will confuse you into thinking that it is somehow related to individual pins. This will be especially true if you are an Ardu-refugee and think in terms of individual pins. It isn't about individual pins. It is about inputting data from all the pins in a port. Hopefully, this will get clear shortly. Okay, now that you've figured out which registers and bits you need to modify and what state to set them, how do you do that in C?

Using AVR Registers in C

You might look at this and think something like, 'Okay, I want to write a 1 to pin 0 of Port B,' so I write:

```
// WRONG!
PORTB0 = 1;
```

But (you complain), the datasheet says the name of that pin is PORTB0, so how come this doesn't work? The answer is that because in the avrlibc I/O header, the #define for PORTB0 is 0. So, all you've written is: 0 = 1; which it isn't. All the PORTB0 define does is provide an alias for the pin number which is 0. So, how do you set PORTB0 to 1?



13.4.2 PORTB – The Port B Data Register

Bit	7	6	5	4	3	2	1	0	
0x05 (0x25)	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	PORTB
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

13.4.3 DDRB – The Port B Data Direction Register

Bit	7	6	5	4	3	2	1	0	
0x04 (0x24)	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	DDRB
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

13.4.4 PINB – The Port B Input Pins Address

Bit	7	6	5	4	3	2	1	0	
0x03 (0x23)	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	PINB
Read/Write	R	R	R	R	R	R	R	R	
Initial Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

■ FIGURE 3. Port B registers.

```
// Right
PORTB |= (1<<PORTB0);
```

Oh bother! That requires those darn bitwise operators. If you think setting the bit to 1 looks weird, how about clearing it to 0:

```
// Clear bit to 0
PORTB &= ~(1<<PORTB0);
```

Yeah, looks sort of like what we learned last month with the bit_set(p,m) and bit_clear(p,m) functions – only now we've taken the armor off. This is real C folks. Tighten your seat belts.

Setting the Pins for Input or Output

Since we want to set the pins to output to control our LCD display, we read in the datasheet:

The DDxn bit in the DDRx Register selects the direction of this pin. If DDxn is written logic one, Pxn is configured as an output pin. If DDxn is written logic zero, Pxn is configured as an input pin.

Set the DDRx bit for the pin of interest to 0 and it is an input. Set it to 1 and it is an output. Let's replace the x with B and see how it is done in our very own port_pin_mode function [int8_t port_pin_mode(uint8_t portx, uint8_t pin, uint8_t mode)] from the elementary digitalio library we discussed in the November and December Workshops:

```
if ( mode == INPUT ) // set DDRB bit to 0
{
        DDRB &= ~(1<<pin);
}
else // ( mode == OUTPUT ) // set DDRB bit to 1
{
        DDRB |= (1<<pin);
}
```

This would be a good time for you to open up port_pin_mode.c [it is in the avrtoolbox repository] in Programmers Notepad to see the actual implementation. So, memorize this: **In 0 out 1**. Or **I0O1**. Or **IzeroOone**. Or **Izzy struck out once**. Or just keep the datasheet handy which is what I do because I can never remember which does what.

Despite the datasheet, we see that it really is simple to set up and use digital input and output, so why even bother with the elementary digitalio library functions? Yeah, my point exactly, but since the Arduino has it and one of my goals with the elementary library — as I say elsewhere — is to provide a C transition for Ardu-refugees, I've included it in the avrtoolbox. Use it. Look at the source. Then move on.

Moving On

For those who want to use C as is was intended (okay, that's an opinion), we initialize the LCD control pins by providing aliases for the relevant port, pin, and data direction registers. Then, we use bitwise operators to set them as shown next. To use the LCD, we must set up four data pins and two control pins which we alias to the definitions in the avrlibc input output header file for the ATmega328 (iom328p.h located in your WinAVR directory ..\avr\include\avr\).

```
// Define the specific ports and pins used for
the LCD
#define LCD_D4_PORT PORTD
#define LCD_D4_DDR DDRD
#define LCD_D4_PIN PD5

#define LCD_D5_PORT PORTD
#define LCD_D5_DDR DDRD
#define LCD_D5_PIN PD4

#define LCD_D6_PORT PORTD
#define LCD_D6_DDR DDRD
#define LCD_D6_PIN PD3

#define LCD_D7_PORT PORTD
#define LCD_D7_DDR DDRD
#define LCD_D7_PIN PD2

#define LCD_E_PORT PORTB
#define LCD_E_DDR DDRB
#define LCD_E_PIN PB3

#define LCD_RS_PORT PORTB
#define LCD_RS_DDR DDRB
#define LCD_RS_PIN PB4
```

To initialize these pins to outputs, we use:

Theory is all well and good, but to really learn this stuff you have to get your hands on some tangible items that blink, whirr, and sometimes detonate. As a service for the readers of the Smiley's Workshop articles, we have simple and inexpensive projects kits available that can help you make it real. You can find these kits (and some darn good books) at the *Nuts & Volts* Webstore.

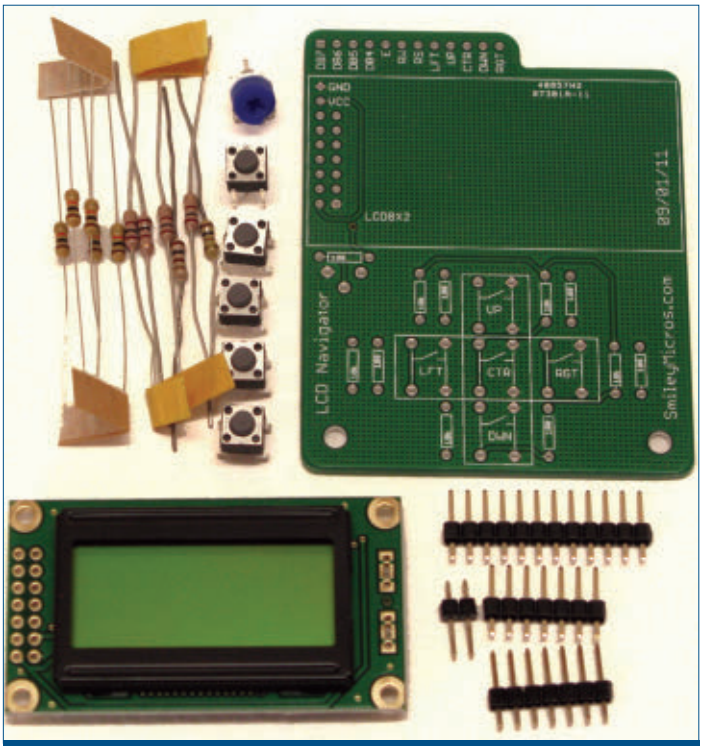
```
// set LCD DDR pins to 1 for output
LCD_D4_DDR |= (1<<LCD_D4_PIN);
LCD_D5_DDR |= (1<<LCD_D5_PIN);
LCD_D6_DDR |= (1<<LCD_D6_PIN);
LCD_D7_DDR |= LCD_D7_PIN);
LCD_E_DDR |= (1<<LCD_E_PIN);
LCD_RS_DDR |= (1<<LCD_RS_PIN);
```

Now the registers are set up so that we can control the LCD. Of course, controlling an LCD of the HD44780 variety is moderately complex, but we'll get to that later.

Lab Section: The LCD Navigator

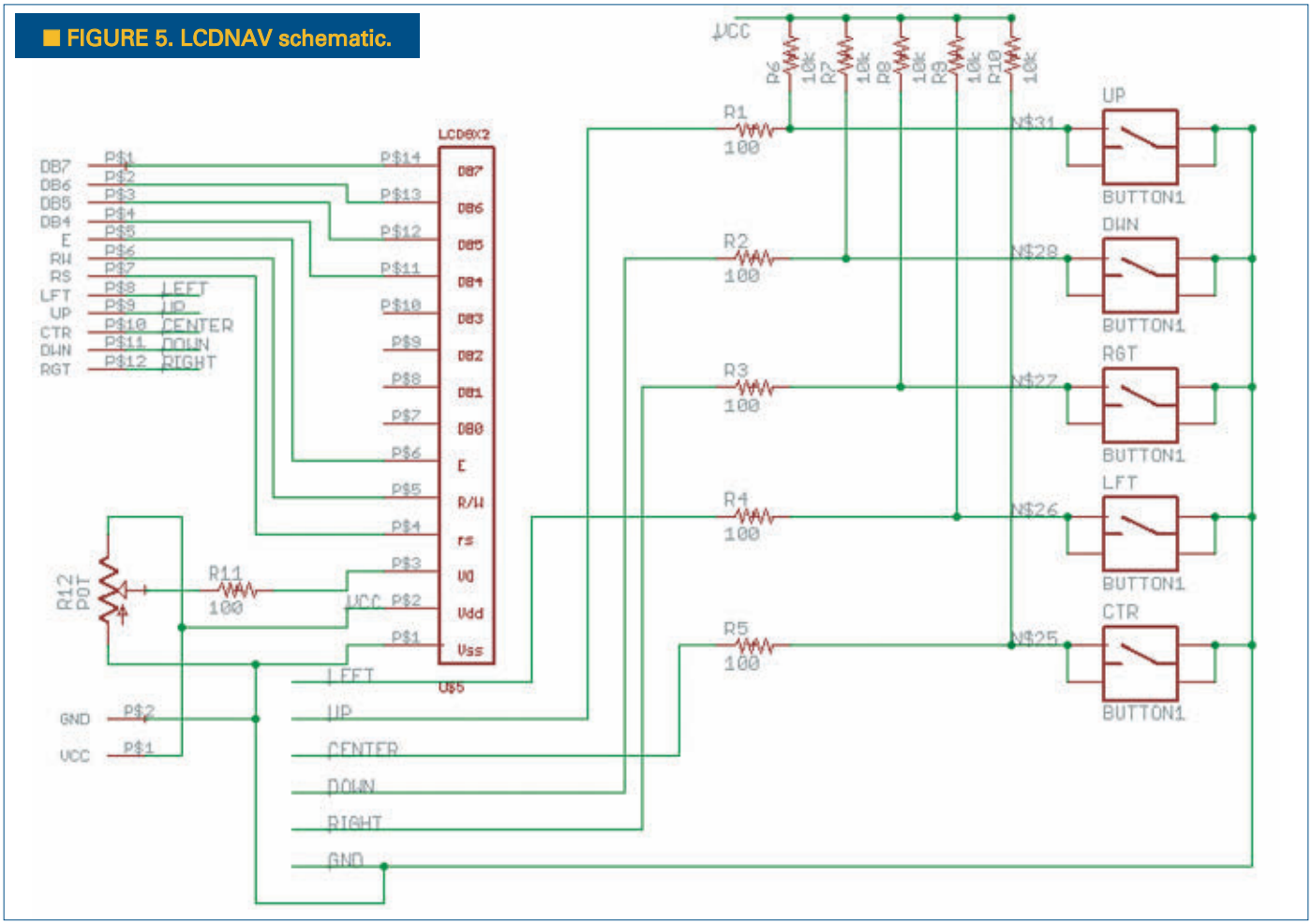
Assemble the LCD Navigator Projects Kit

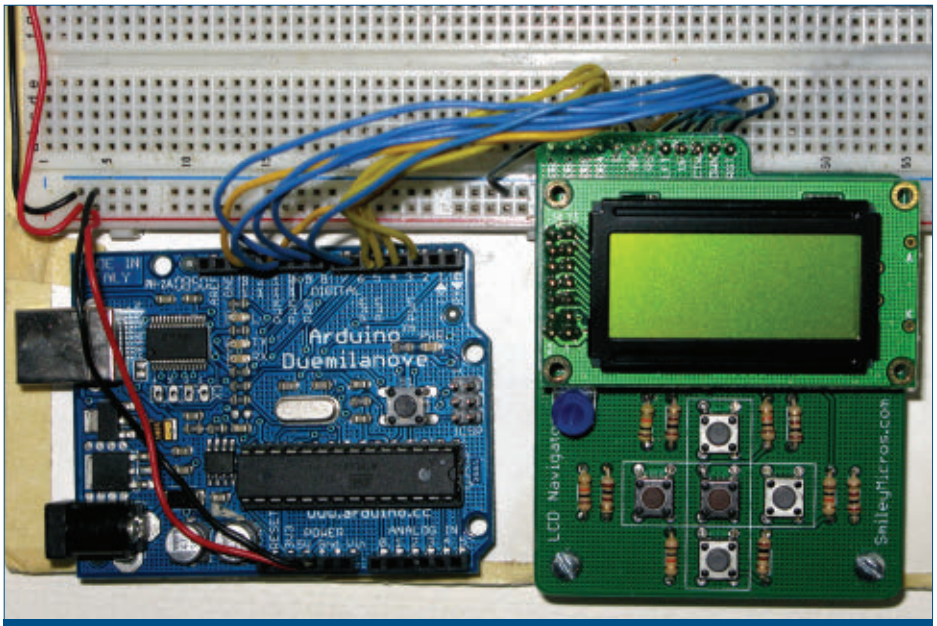
The LCD Navigator Projects Kit (shown in **Figure 4**) is available from the *Nuts & Volts* webstore.



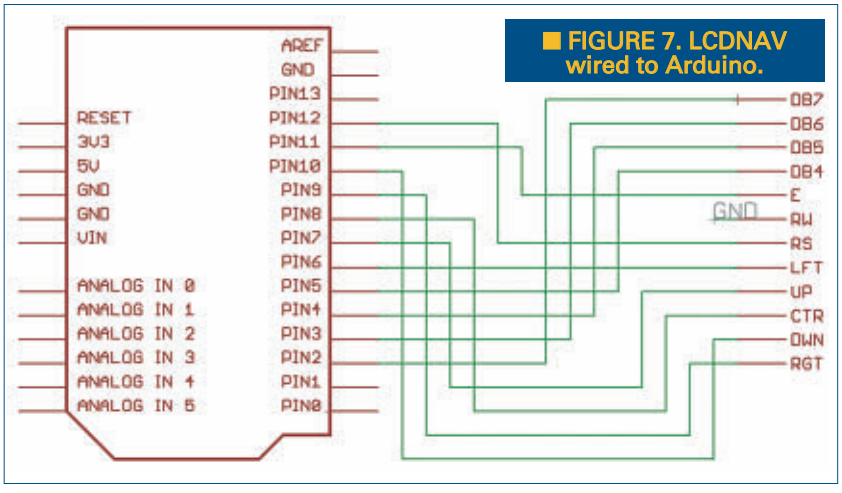
■ FIGURE 4. LCD Navigator parts kit.

■ FIGURE 5. LCDNAV schematic.





■ FIGURE 6. LCDNAV with Arduino.



■ FIGURE 7. LCDNAV wired to Arduino.

Instructions on assembling the board are available on **www.smileymicros.com** under the LCDNAV menu. The schematics for this board are shown in **Figure 5**.

LCD Hardware: The HD44780 LCD

I read a book (I think it was David Brin's *Practice Effect*) where some primitive people found a digital watch with an LCD display. They were amazed that whoever made the thing was able to train all the little black bugs to run around and align themselves in such peculiar patterns. That's the extent of the detail I'll give on the underlying technology of LCDs. We'll concentrate instead on using C to train the little black bugs to do our tricks.

We are lucky since Hitachi developed a simple way to control the LCD that has now become an industry standard for low cost character LCDs: the HD44780 driver/controller chip that you'll find built into our display. They provide a parallel control interface that can send data in either eight-bit or four-bit chunks, and control the communication with enable and read strobe lines. Since we like to save pins in our AVR designs, we will use the four-bit mode. Of course, all that brain fatiguing stuff we learned about bitwise operators is going to come in handy.

Wiring LCDNAV to the Arduino

Well, after all that preaching to get folks to drill down through the simpler library functions and use the underlying C, we are going to do our first demonstration of the LCD Navigator with the Arduino! Not really. We will only be using the board and do the code in C using AVRStudio, WinAVR, and avrdude. The Arduino is an easy to use development platform and you don't have to use the Arduino IDE or libraries — you can use it with plain old C. You can see how to wire this up in **Figure 6** and **Figure 7**.

LCDNAV wiring to the Arduino is as follows:

- DB7 Pin 2
- DB6 Pin 3
- DB5 Pin 4
- DB4 Pin 5
- E Pin 11
- RW GND
- RS Pin 12
- LFT Pin 6
- UP Pin 7
- CTR Pin 8
- DWN Pin 10
- RGT Pin 9

LCD Software

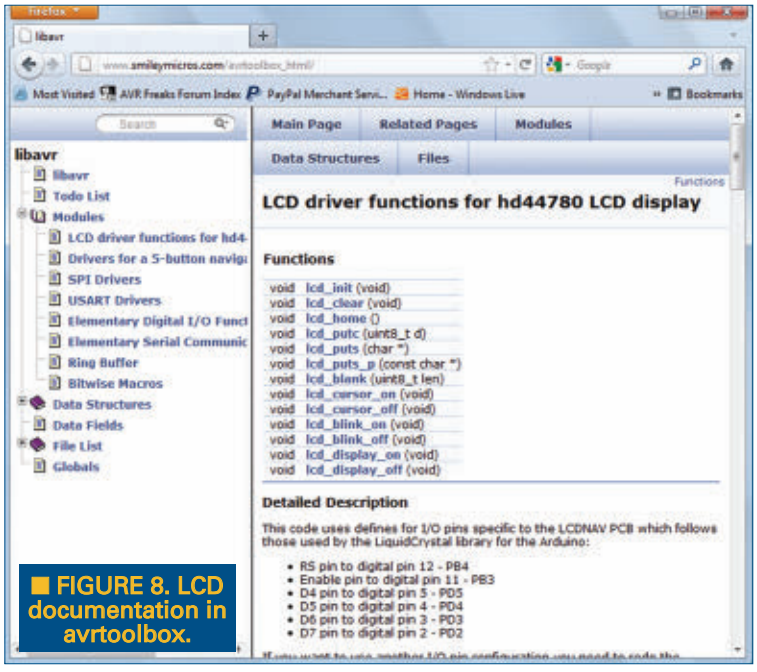
Using the LCD

We will use our avrtoolbox LCD elementary library which somewhat duplicates the function in the Arduino LiquidCrystal library (but in a more generalized fashion) to use with the regular AVR C tools: AVRStudio, WinAVR, and avrdude. The source code is located in avrtoolbox\libavr\testers\source \ lcd_hd44780. I owe a debt to Peter Dannenger for his LCD tutorial on AVRFreaks. His code provided a good starting point for porting the Arduino LiquidCrystal functions [**www.avrfreaks.net/index.php?name=PNphpBB2&file=viewtopic&p=828978**]. You can find the source code for this library at **http://code.google.com/p/avrtoolbox/libavr/source/driver/external_hardware/lcd-hd44780**. The library has the following functions:

```
lcd_init()
lcd_clear()
```

```
lcd_home()
lcd_set_cursor()
lcd_putc()
lcd_puts()
lcd_puts_p()
lcd_cursor_on()
lcd_cursor_off()
lcd_blink_on()
lcd_blink_off()
lcd_display_on()
lcd_display_off()
```

As shown in **Figure 8**, you can access the avrtoolbox documentation at **www.smileymicros.com\avrtoolbox_html**.


libavr
Main Page
Related Pages
Modules
Data Structures
Files
LCD driver functions for hd44780 LCD display
Functions
Detailed Description
This code uses defines for I/O pins specific to the LCDNAV PCB which follows those used by the LiquidCrystal library for the Arduino:
RS pin to digital pin 12 - PB4
Enable pin to digital pin 11 - PB3
D4 pin to digital pin 5 - PD5
D5 pin to digital pin 4 - PD4
D6 pin to digital pin 3 - PD3
D7 pin to digital pin 2 - PD2

■ FIGURE 8. LCD documentation in avrtoolbox.

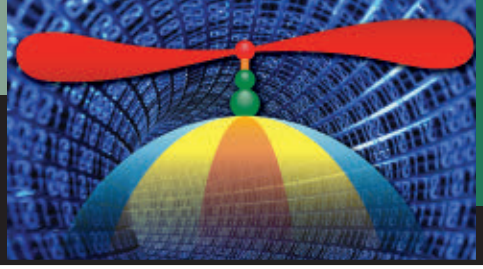
Yes, but can you use it with the Arduino?

I'm really not trying to make folks lives more complex than necessary, but you can use the LCD with the Arduino LiquidCrystal library. It is wired up for it, anyway. The only caveat is that their code is for a 16x2 (16 characters, two lines) LCD while our LCDNAV board uses a 8x2 LCD (it is a lot cheaper). You need to change one line in each example: from lcd.begin(16, 2); to lcd.begin(8, 2);. Note that this doesn't make a difference in some of the examples since they are hardwired to 16 characters. I suggest sticking with the avrtoolbox code for now.

Well, as usual, we stop in the middle of things. For now, you can wire this up as shown and use it with several applications at **http://code.google.com/p/avrtoolbox/**. These include tester programs for the LCD and Nav button libraries and an LCDNAV_demo program in the avr_application directory. Have fun playing with it and we'll get more of the details in later Workshops. Next month, we'll look at the Navigator buttons and a menu application for the LCD Navigator project.

Questions? *Nuts & Volts* is hosting forums for its writers and you can find mine at **http://forum.servomagazine.com**. If you want a really quick response — especially to a question not directly related to an article — you can put on your biohazard suit and start a thread at **www.avrfreaks.net**. (First, read my blog entry that will tell you why you need the biohazard suit at **http://smileymicros.com/blog/2011/01/24/using-an-internet-forum**.)

If you just can't wait and want to get a leg up on all this serial stuff and real C programming for the AVR (while helping support your favorite magazine and technical writer), then buy my *C Programming* book and Butterfly projects kit and the *Virtual Serial Port Cookbook* at the *Nuts & Volts* webshop. **NV**



SPIN ZONE

ADVENTURES IN PROPELLER PROGRAMMING

■ BY JON WILLIAMS

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

PROP TALK

From time to time, I just want to tell my Propeller project what to do — and it seems others do, as well. In recent months, I've worked with many who have asked about passing information between a PC and the Propeller, or even Propeller to Propeller. My focus will be on the former, that is, using a terminal to exchange information with the Propeller. What I needed was a protocol, and there are certainly any number of those available. Cutting right to the chase, I created my own called HFCP: for Human Friendly Control Protocol. Yep, cheesy name — but very easy to use. Now, this isn't going to be appropriate for everything you develop, but for small projects that want to "talk" to you via your PC, this works really well.

So, what makes HFCP human friendly? Well, it's text based so that we can use a simple terminal to exchange information. Secondly, it uses (by default) decimal values so we don't have to decode anything. If you've ever looked at a MODBUS ASCII stream, you know what I'm talking about. Of course, I'd love to have you think that I'm some wildly clever guy. The fact is, I'm a regular guy who knows a good idea when he sees one. The idea for my protocol structure came from GPS.

GPS strings (NEMA 0183) are easy to read: plain ASCII text with fields separated by commas and terminated with a carriage return. The values are decimal — easy. Having worked on a GPS parser last year, I knew that if I adopted GPS string properties I could adapt some existing code. As you know, the devil is in the details and it did take a bit of time to get everything together — especially with the features I decided to add — but it's done now, ready to use, and it works very nicely.

HFCP BASICS

A message from the system master (usually a PC) will start with the ">" character. The header is followed by two or more fields, and the fields are separated with commas. Spaces and a few special characters in the message are tolerated. The structure is as follows:

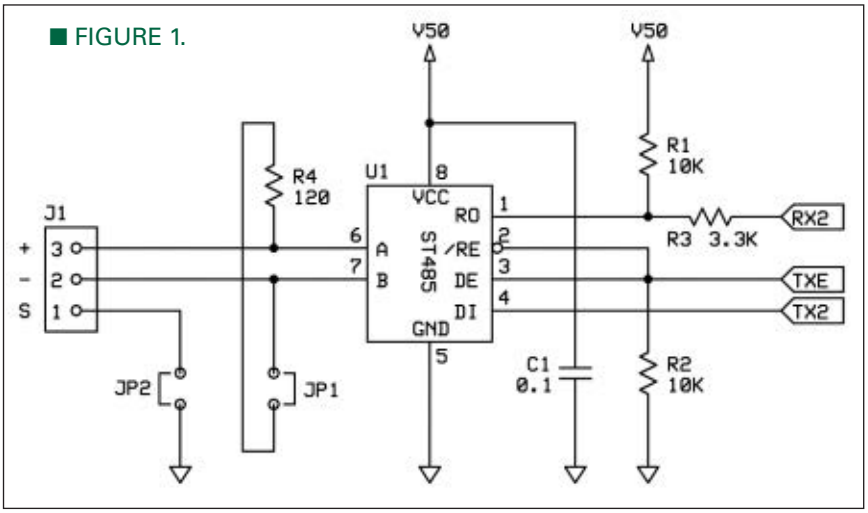
```
>target, command, parameters, value1, … ,
value8<CR>
```

In my stock version, I can support a message with up to eight parameters. If your applications tend to require more values, you can easily change the P_MAX constant in the object. What I should note is that — other than the terminating CR — all fields are numeric. Thus we have our first, "Shoot, how do I get around that?" moment when actually working through a project.

If we want to transmit text in a message, there is a special message type: The parameters value is specified as the "@" character and the text is placed in the fourth field. Later, we'll see how we can determine which kind of message was received (numeric versus string).

Some messages will not require any

■ FIGURE 1.



data, so the shortest possible message contains only the target address and the command value.

HFCP IN ACTION

In order to keep this very lightweight, the HFCP object is simply a set of methods that we will use with our favorite serial driver. Using a PC, for example, that will usually be *FullDuplexSerial* or one of its many derivatives. As you saw in the previous discussion, the message contains the target address so it is intended to operate on "networked" systems. I do a fair bit of work with RS-485 and have written a half-duplex driver (see *jm_hd485.spin*) that handles the hardware handshaking of the RS-485 circuitry. You'll find that file in the downloads, and **Figure 1** is my favorite circuit for connecting the Propeller to a half-duplex RS-485 buss.

In order to use HFCP, we have to do a little bit of work — it's not simply "plug and play," and neither is it difficult. Here's a simple shell example that we might use:

```
pub main | t, c

  serial.start(RX1, TX1, %0000, 115_200)
  hfcp.start

  t := cnt
  repeat
    c := serial.rxcheck
    if (c => 0)
      hfcp.enqueue(c)
      if (hfcp.has_msg)
        process_msg

    waitcnt(t += clkfreq >> 5)
```

In this example, we're starting the serial object and connecting it to the Propeller's programming port at 115.2K baud. The HFCP object has a **start** method that doesn't require any parameters; this method simply resets all its internal variables.

Receiving characters is handled in a synchronized loop that runs 32 times per second. This isn't particularly zippy, but it's much faster than you or I can type command strings into a terminal. Note that we are using the **rxcheck** method — this is very important. We may need to do other things in the loop and don't want to get hung up at this point. By using the **rxcheck** method, we'll get a return value of -1 if there is nothing in waiting in the serial RX buffer.

Let's assume that a character has arrived. It gets moved to the HFCP object using the **enqueue** method. Enqueue is fancy-schmancy for "put it into a buffer." The next step is to check for the presence of a complete message; when that is true, the program will handle it.

Obviously, there's more than meets the eye to the **enqueue** method, so let's have a look:

```
pub enqueue(c) | fc

  if ((qidx == 0) and (c <> REQ_HDR))
    return

  else
    if ((c <> EOM) and (c <> 0))
      queue[qidx++] := c
    else
      reset
      fc := field_count
      if (fc => 2)
        msgtype := parse_fields

      bytefill(@queue, 0, Q_LEN+1)
```

In the very beginning, I told you that a master-to-node message must start with the ">" character (this is defined in the REQ_HDR constant). If we are at the beginning of the message queue (*qidx* is zero), the program will wait for the proper header before moving on. Once things get going, we'll watch for the end-of-message character which I've defined as carriage return (13). As you can see, we simply add characters after getting the header and stop when we get an appropriate EOM.

You may be wondering why *qidx* is not defined locally. The reason is that we need to preserve this value between calls to the method; hence, it's in the object's global variables definitions.

When the end-of-message is detected, all internal message type and parameter variables are reset and then the number of fields in the message is counted; if the count is two or more, the fields of the message are parsed/converted and made available. Counting fields is simply a matter of counting the number of separator characters (comma or EOM) in the message. When the EOM character is detected, the loop is aborted and the number of fields in the message is returned:

```
pub field_count | fc, idx

  fc := idx := 0

  repeat
    case queue[idx++]
      FLD_SEP:
```

BILL OF MATERIALS

Item	Description	Mouser Part #
R1-8	220 ohms	299-220-RC
C1	0.1 µF	594-K104K15X7RF5TH5
J1	Terminal	571-2828363
JP1a,JP2a	0.1 header	517-6111TG
JP1b,JP2b	Shunt	517-950-00
R1,R2	10K	291-10K-RC
R3	3.3K	291-3.3K-RC
R4	120	293-120-RC
U1	ST485B	511-ST485BN

```
          ++fc

        EOM, 0:
          ++fc
          quit

    return fc
```

Parsing the fields is a little more involved; the first thing we need to know is where a particular field is located in the message string. For this, the **field_pos** method is used. This takes a zero-indexed field number and returns its position. If the field number passed is not valid for the message, then -1 is returned:

```
pri field_pos(fn) | idx

  if (fn < 0)
    return -1

  idx := 0

  repeat while (fn > 0)
    case queue[idx++]
      FLD_SEP:
        --fn

      EOM, 0:
        idx := -1
        quit

  return idx
```

The position of the desired field is located by iterating through the characters in the message, decrementing the field number value when a separator is encountered. When the field number hits zero, we're sitting on the position of the desired field in the message and that is returned to the caller.

The final step is to extract and convert the various fields and make them available to the calling application; this is handled with the **parse_fields** method:

```
pri parse_fields | pos, fc, idx

  reset

  taddr := strings.asc2val(@queue[1])

  pos := field_pos(1)
  cmd := strings.asc2val(@queue+pos)

  pos := field_pos(2)
  if (strings.instr(@queue, string(STR_MSG))
  => 0)
    pos := field_pos(3)
    bytemove(@tfield, @queue+pos,
    strsize(@queue+pos))
    return MSG_STR

  pcount := strings.asc2val(@queue+pos)

  if (pcount > 0)
    pcount <#= P_MAX
    repeat idx from 0 to pcount-1
      pos := field_pos(3+idx)
      param[idx] := strings.asc2val
      (@queue+pos)

  return MSG_NUM
```

At the top, we're going to reset all the internal variables; this sets all values returned to the user to zero since we don't know how many parameters are included in the next message. We use zero because the parser allows for positive and negative values (signed, 31 bits).

The first thing extracted is the target address for the message. This is removed from the message using the **asc2val** method from the strings object. Over the last year or so, I've been collecting and translating useful string functions and I finally stuck them all into a handy object. The target address is in field 0 of the message, so we don't have to use **field_pos** for this one. We do have to skip over the header, though, as the parser only allows for spaces, identifiers, and numeric characters.

The next field extracted is the command. We do need to use **field_pos** here because we don't know how long the target address field is. That's the nice thing about this simple little protocol: The fields can be variable width, so entering values in a terminal program is quite easy.

The final mandatory extraction is the parameters count. You'll remember that this field has a special case: When we transmit a string message, the parameters count is set to "@." We can look for this using the **instr** method and if it's found, the string in field three is copied to an internal byte array called *tfield*. The **parse_fields** method exits with a return value of MSG_STR (2).

Simple command messages will have a parameter count of zero, so we can bypass the parameters extraction. When a message does have parameters, a loop finds and extracts them from the message. Numeric messages return a value of MSG_NUM (1) from **parse_fields**.

Okay, time to put this stuff to work. Here's an update to the demo loop I presented earlier. As you can see, I'm running the loop using a fixed timing value and using that to drive a simple timer/rtc that our project can use:

```
pub main | t, c

  setup
  serial.tx(CLS)

  t := cnt
  repeat

    c := serial.rxcheck
```

```
        if (c => 0)
          serial.tx(c)
          hfcp.enqueue(c)
          if (hfcp.has_msg)
            qualify

        if (++timer[T_TIX] => (1_000 / LOOP_MS))
          timer[T_TIX] := 0
          if (++timer[T_SECS] => 60)
            timer[T_SECS] := 0
            if (++timer[T_MINS] => 60)
              timer[T_MINS] := 0
              if (++timer[T_HRS] => 24)
                timer[T_HRS] := 0

        waitcnt(t += constant(LOOP_MS * MS_001))
```

Let me jump up on a soap box for just a second. It's easy for all of us to ask, "Where's the object for that?" This behavior is not limited to Propeller programmers; it's human nature. A good friend in the special effects business says the running joke in that industry is new animators asking, "Where's the dinosaur plug-in?" Remember that there was a time when we didn't have eight processors at our disposal and we did seem to get along, albeit with more work. Still, there are times when it is not necessary to launch another cog for a simple process.

The bare-bones timer/rtc here is a perfect example. It's just a few variables and a few lines of code. My favorite aspect of Spin is that we can run "foreground" loops with precise timing (remember the old days of padding loops to make the timing work out?) and with that, we have tremendous power. Okay. I think you get my point. There won't always be a ready-made object for everything, and sometimes a few lines of code is enough.

The top part of the loop checks for, displays, and enqueues characters. When a message is detected, the **qualify** method is called to deal with it. When that returns, the timer/rtc is updated. Easy, right? Absolutely!

Okay, then. Let's try some messages. Let me explain the goals here first. It's clear to you that follow my column I love lighting control, so I dropped the LED modulator from last time into the program and now I can control LEDs from a terminal. If I connect this to an RS-485 system, I can control any number of LEDs from long distance.

The demo commands are simple:

```
0         Set all channels to same level
1..8      Set specific channel to level
9         Set all channels using digital
          value
11..18    Return channel level
20        Display string message
90        Read timer/RTC
91        Set timer/RTC (for use as clock)
92        Clear timer/RTC (for use as timer)
```

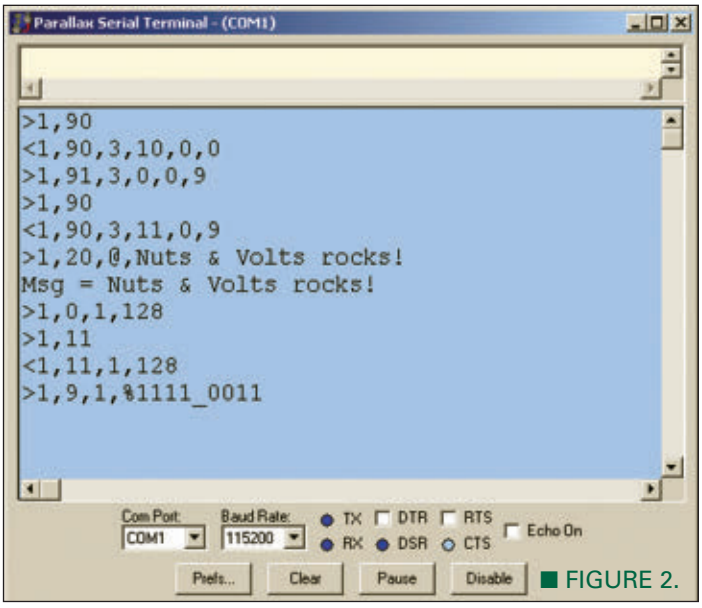
Messages are qualified and dispatched with the **qualify** method:

```
pub qualify

  if (hfcp.target == MY_ADDR)
    case hfcp.has_msg
      hfcp#MSG_NUM:
        process_num

      hfcp#MSG_STR:
        process_str

  hfcp.clear_msg
```

The important step here is to qualify the target address of the message; if it is not intended for this node, then there's nothing to do except clear the message flag. If the last message was intended for this node, then it is dispatched to the particular handlers based on the message type (numeric or string).

Most of the messages for this node are the numeric type; some (like read clock, #90) take no parameters, while setting the clock (#91) requires three. Here's the numeric message handler:

```
pub process_num | cmd, n

  cmd := hfcp.command
  n   := hfcp.p_count

  case cmd
    0:
      if (n == 1)
        leds.set_all(hfcp.p_read(1))

    1..8:
      if (n == 1)
        leds.set(cmd-1, hfcp.p_read(1))

    9:
      if (n == 1)
        leds.dig_set(hfcp.p_read(1))

    11..18:
      if (n == 0)
        hfcp.write(1, leds.read(cmd-11))
        hfcp.build_msg(MY_ADDR, cmd, 1)
        serial.str(hfcp.response)

    90:
      if (n == 0)
        hfcp.write_block(3, @rtc[T_SECS])
        hfcp.build_msg(MY_ADDR, cmd, 3)
        serial.str(hfcp.response)

    91:
      if (n == 3)
```



■ FIGURE 2.

```
            rtc[T_TICS]  := 0
            rtc[T_SECS]  := 0 #> hfcp.p_read(1)
            <# 59
            rtc[T_MINS]  := 0 #> hfcp.p_read(2)
            <# 59
            rtc[T_HRS]   := 0 #> hfcp.p_read(3)
            <# 23

        92:
          if (n == 0)
            longfill(@rtc, 0, 4)
```

We start by retrieving the command and parameters count from the message, then drop into a **case** structure that handles the messages known to this node. The parameters count helps further qualify each message, especially in the case where one or more parameters are required.

As you can see, it's very straightforward stuff. Remember that we are calling this from the middle of our main loop, so we dare not dally. Let me point out a little "Easter egg" that I neglected to mention earlier.

If you look at command #9, you'll see that it takes a single parameter and then calls the **dig_set** method (new to the LED modulator) to set the LEDs. This method treats the outputs like a standard parallel port; we turn on an LED with a "1" bit in the parameter and a "0" bit will extinguish the LED for that position. So, if we wanted to turn on the MSB LED and extinguish the others, we could do something like this:

```
>1,9,1,128
```

Most of us know that 128 is the MSB bit of a byte, but what happens when we want to set three or four random bits, and it's not an easy to remember value? No worries! The **asc2val** method in the strings library can deal with binary values — so long as they're indicated.

I took a page from the BASIC Stamp and Propeller editors: They allow us to use binary and hex values in our code; we alert the compiler by using special symbols. What this means is that the command above can be changed to:

```
>1,9,1,%1000_0000
```

And, yes, the parser also allows the use of the underscore character to separate groups of digits in a number. As with the editors we use, $ is the designation for hexadecimal values.

Now have a look at command #90; this requires no parameters but does give something back (the current values in our timer/rtc). The **write_block** method is used to quickly transfer the working values of the timer/rtc to the parameters list in the HFCP object. Since that list uses longs, we use longs for the timer/rtc values to accommodate this transfer. The next step is to build the output message which — like the input — will be a string with comma-separated fields. The difference is that the response string will use "<" as its header. This allows us to monitor a system and distinguish between command and response messages.

The **build_msg** method is used and we will pass the response address, the command we're responding to, and the number of parameters to have in the response message. Now, you understand why we loaded the parameters first. Finally, we can send the message by using the **str** method of our serial object.

So, there you have it. An easy protocol handler that will simplify talking to your Propeller projects. Have a look at **Figure 2** for an exchange with the demo program.

Of course, there are features we don't have space to cover, like the ability to set the numeric style (decimal, binary, hex) of parameters in the response message, etc. I know that those of you who have experience in data communications are asking, "Where's the checksum?" You're right. In this version, that doesn't exist. It's an easy add, though, and down the road I will take another page from the GPS strings and use the "*" symbol to indicate that there is a checksum appended to the message. This will be optional, of course, and will only apply when the messages are being generated by a computer — be it another Propeller or a PC on the network.

Okay, then. Load up the demo and start talking. This "talking" stuff is really a lot of fun and we will continue next time. If you missed Fred Eady's excellent article on CAN networking (November '11), you may want to go read it as that's where we're headed next. We'll build a CAN module for the Propeller Platform and I'll show you how to put it to use. It's really neat stuff.

Until next time, Happy New Year and keep spinning and winning with the Propeller! **NV**

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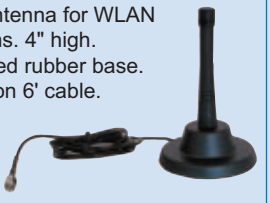

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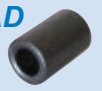

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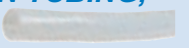

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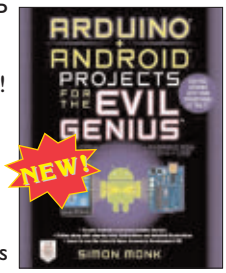

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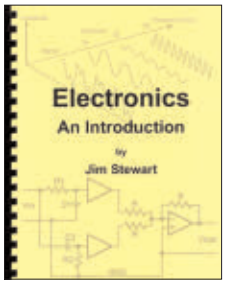

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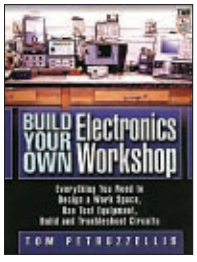

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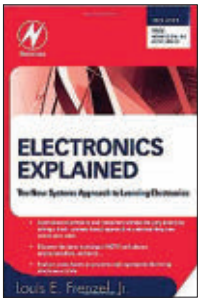

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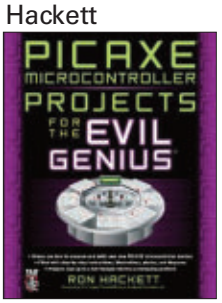

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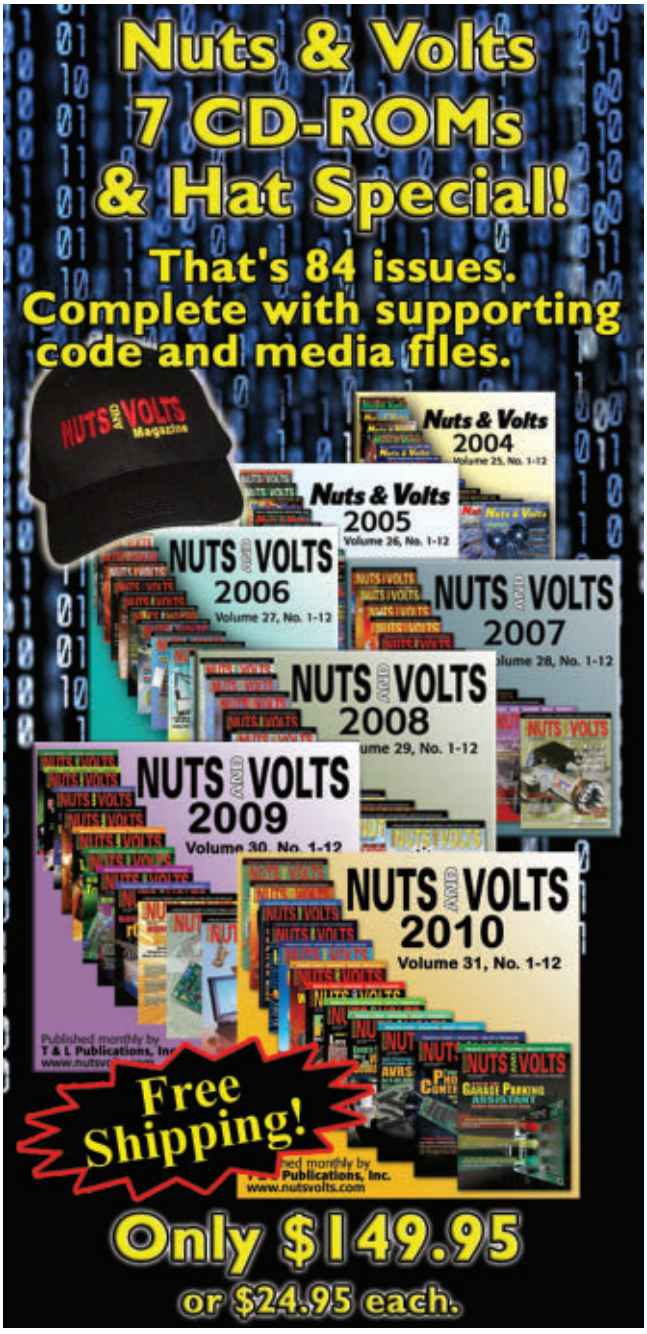

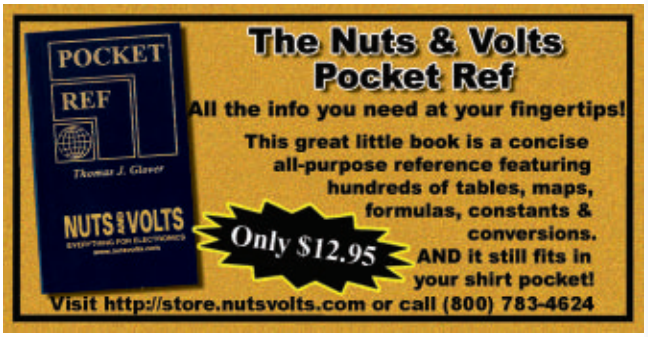
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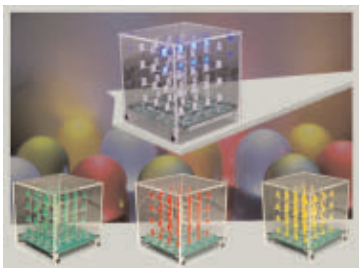

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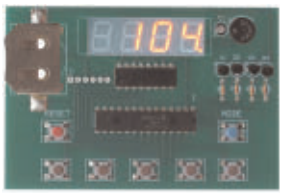

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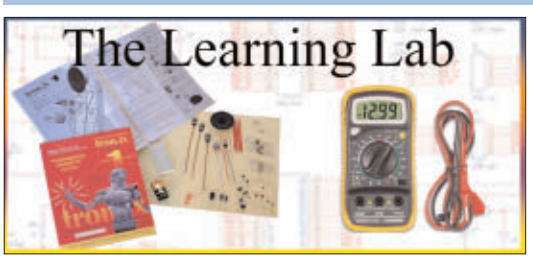

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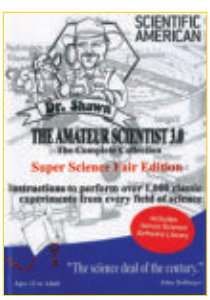

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■ BY FRED EADY

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MPLAB'S X FACTOR

I heard it, I heard it, I heard it on the X. **Those famous words are the lyrics to a ZZ Top tune entitled — you guessed it — Heard It On The X. The "X" radio stations were Mexican super-high-powered 250,000 watt AM operations that broadcasted religious programs and all kinds of music from just across the Texas-Mexico border. Wolfman Jack became famous in the 1960s working his magic on the X stations. I can remember catching the X late at night on the AM band of my multi-band shortwave receiver.**

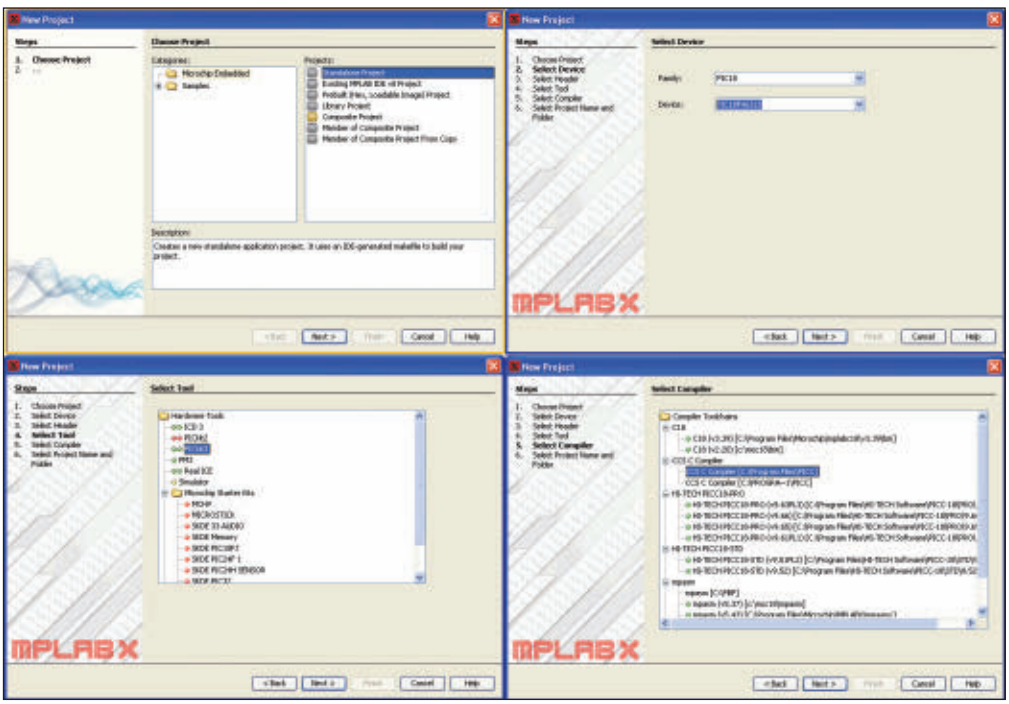
During the 2010 MASTERS Conference, I saw it on the "X"... MPLAB X, that is. MPLAB X has come a long way since its inception. In addition to the Microchip line of C compilers, MPLAB X now supports the CCS C compiler and microEngineering Labs new PICBASIC PRO compiler 3.0. If you want to use your MAC to create PIC firmware with MPLAB X, now you can. MPLAB X is also Linux friendly.

MPLAB X VERSUS MPLAB IDE

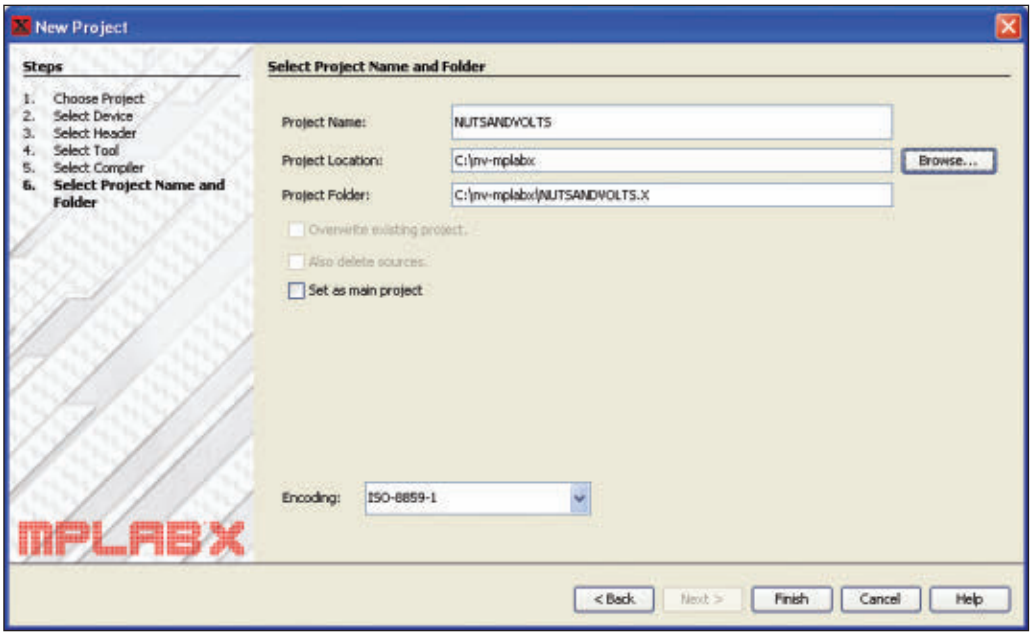
The MPLAB 8 IDE is a workspace-oriented development tool. That is, the project's source code, hardware tool (programmer/debugger) information, and target microcontroller (device) information are all contained within the project workspace. Conversely, the MPLAB X development tool is project oriented. Everything associated with the project (hardware tool, compiler, device, etc.) is contained within the scope of the project. Since each MPLAB X project is a self-contained entity, multiple projects using differing programmers/debugging devices, PIC devices, and compilers can be debugged simultaneously within the MPLAB X environment.

The root of any MPLAB X project is the source code. Multiple configurations can be built around a central piece of source code that is common to the project. This MPLAB X design point allows you to run differing hardware tools and PIC devices against the project's common source code root within the same project.

Device memory is presented in precast memory windows within the MPLAB 8 IDE. The latest version of MPLAB X also allows the use of precast memory views. However, MPLAB X takes it one step further. Each memory view can be changed to an alternate view on the fly. The format selection of the memory views in the MPLAB X



■ SCREENSHOT 1. This is a composite capture of the steps taken to create a new MPLAB X project. The PIC18F465J13 does not have an associated hardware header, so the Select Header step is ignored.



■ SCREENSHOT 2. This step in the MPLAB X new project process allows us to place the new project in a user-selected folder.

environment has also been simplified. Instead of accessing a drop-down menu to select a data format view — which is the way of MPLAB 8 IDE — the format of an MPLAB X memory window's data view can be changed within the memory window.

While the MPLAB X differences are fresh in our minds, let's create an MPLAB X project called *NUTSANDVOLTS* and examine the areas of MPLAB X we just discussed. Take a look at **Screenshot 1**. Step 1 in creating a new MPLAB X project requires that we select a project type. In that we want to spawn a totally new project, a Microchip Embedded Standalone Project will do nicely.

Moving to Step 2, we are prompted to select a target microcontroller (device). Today, I happen to be intrigued by the PIC18F46J13 and I happen to have that PIC mounted on an EDTP general-purpose development board.

It is possible that the selected device has an optional hardware header. There is no hardware header for the PIC18F46J13. So, Step 3 is skipped.

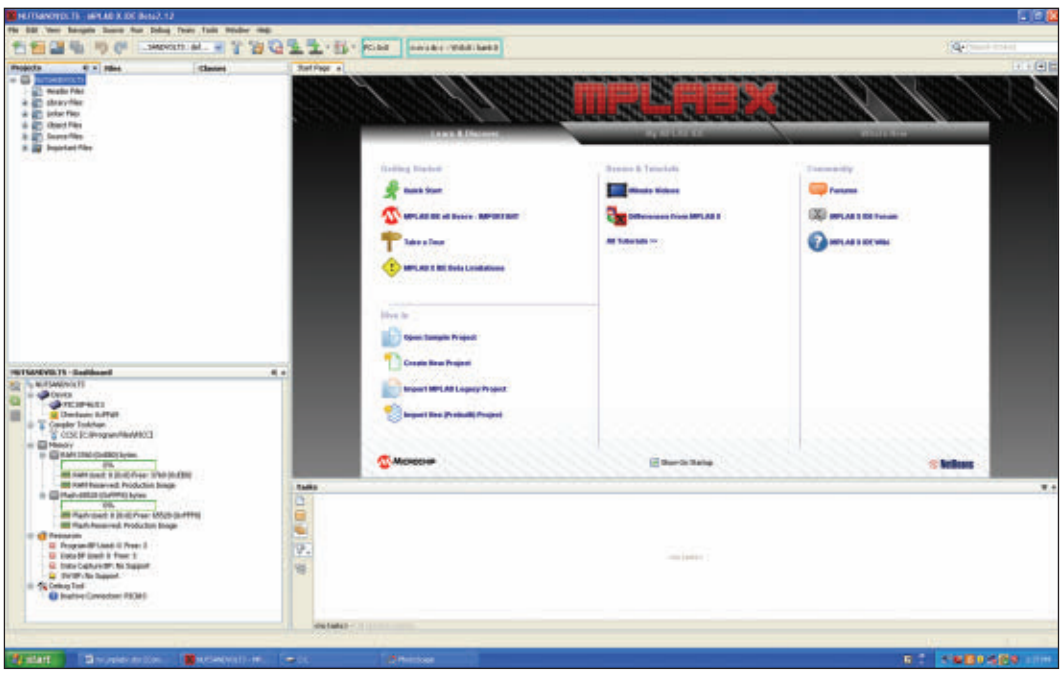
The tool is selected in Step 4. Note that the PICkit2 does not support the PIC18F46J13. However, the PICkit3 is highlighted by a couple of green lights. So, the PICkit3 is our tool in this configuration.

The compiler of choice is the CCS C compiler. Every compiler loaded on my laptop is listed as available in Step 5. Yes. I have them all.

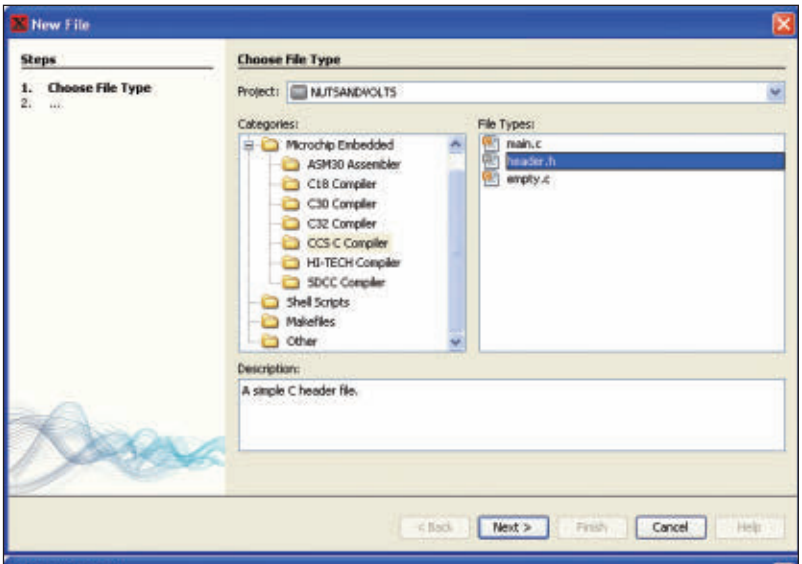
Screenshot 2 is the final step in the MPLAB X new project creation process. As you can see, our new project *NUTSANDVOLTS* resides in the *NUTSANDVOLTS.X* folder, which lies inside of the *nv-mplabx* folder. We have no source code, so **Screenshot 3** is a skeleton of our new project. In that there's no gas in the tank, the Dashboard view is a null presentation. Note that the PICkit3 is dormant. That's because MPLAB X does not use the PICkit3 when not debugging or programming.

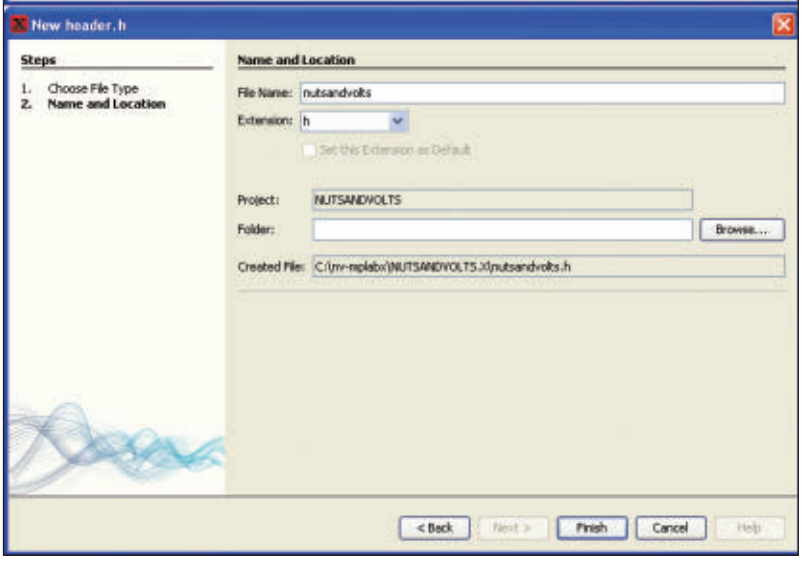
This seeming snub has its advantages. Since we know that we can run multiple debugging sessions, it makes sense that the tool should not be hogged by a single project. If we're forced to share a single tool among multiple MPLAB X projects, only the project that is running a debug or programming session seizes control of the PICkit3 tool. When that project finishes with the tool, it releases it for use by other projects.

Looking at 0xFF and 0x00 characters in memory views doesn't do a thing for me. So, let's crank up the CCS C compiler and generate some header code for the



■ SCREENSHOT 3. Here we are. All dressed up and nowhere to go.





■ SCREENSHOT 4. Here again, the creation of a file can be performed manually. Why do it by hand when you can call upon MPLAB X to do the job and format the file for the CCS C compiler automagically? As you can see, I've asked MPLAB X to create a properly formatted CCS C header file called nutsandvolts.h.

PIC18F46J13. Once that's done, we'll put a bit of CCS C source to use it.

ADDING FILES TO OUR MPLAB X PROJECT

Yes. We could create all of the necessary PIC18F46J13 fuse information manually. However, the CCS compiler creates fuse, clocking, and RS-232 configuration values without breaking a sweat. So, I ran its PIC Wizard to create the *nutsandvolts.h* file contents. I could just copy the CCS C-generated file to my MPLAB X project file, but that's just dull. Let's exploit yet another cool feature of MPLAB X. We'll create the MPLAB X-approved *nutsandvolts.h* file using the new file feature that is part of MPLAB X. In Step 1 of **Screenshot 4**, I chose to create a CCS compiler header file. The only typing I had to do was to give the new header file a name. Everything else was filled in by MPLAB X. All that's left to do is cut and paste the CCS C-generated file filler into our new *nutsandvolts.h* file.

For those of you that are not familiar with the configuration header file created by the CCS PIC Wizard, here is the final *nutsandvolts.h* file contents we will use with our C source code:

```
/*
 * File:   nutsandvolts.h
 * Author: Fred
 *
 * Created on November 1, 2011, 2:53 PM
 */
#include <18F46J13.h>
#device ICD=TRUE

#FUSES NOWDT          //No Watch Dog Timer
#FUSES WDT128         //Watch Dog Timer uses
                      //1:128 Postscale
#FUSES PLL1           //No PLL PreScaler
#FUSES NOPLLEN        //4X HW PLL disabled, 4X
                      //PLL enabled in software
#FUSES STVREN         //Stack full/underflow will
                      //cause reset
#FUSES NOXINST        //Extended set extension
                      //and Indexed Addressing
                      //mode disabled (Legacy
                      //mode)
#FUSES DEBUG          //Debug mode for use with
                      //ICD
#FUSES NOPROTECT      //Code not protected from
                      //reading
#FUSES HS      //High speed Osc (> 4mhz for
               //PCM/PCH) (>10mhz for PCD)
#FUSES SOSC_HIGH      //High-power SOSC circuit
                      //is selected
```

SOURCES

Custom Computer Services
CCS C Compiler
www.ccsinfo.com

Microchip
MPLAB X
PIC18F46J13
www.microchip.com

microEngineering Labs
PICBASIC PRO Compiler 3.0
www.pbp3.com

```
#FUSES NOCLOCKOUT
#FUSES NOFCMEN        //Fail-safe clock monitor
                      //enabled
#FUSES NOIESO         //Internal External Switch
                      //Over mode disabled
#FUSES DSWDTOSC_INT           //DSWDT uses INTRC
                              //as reference clock
#FUSES RTCOSC_T1      //RTCC uses Secondary
                      //Oscillator as reference
                      //source
#FUSES NODSBOR        //BOR disabled in Deep
                      //Sleep
#FUSES NODSWDT        //Deep Sleep Watchdog Timer
                      //disabled
#FUSES DSWDT2147483648        //DSWDT uses
                              //1:2147483648
                              //Postscale
#FUSES NOIOL1WAY      //Allows multiple
                      //reconfigurations of
                      //peripheral pins
#FUSES ADC10          //ADC is 10-bits
#FUSES MSSPMSK7       //MSSP uses 7 bit Masking
                      //mode
#FUSES WPFP
#FUSES NOWPCFG        //Configuration
                      //Words page is
                      //erase/
                      //write-protected
#FUSES WPDIS  //All Flash memory may be
              // erased or written
#FUSES WPBEG          //Flash pages 0 to
                      //WPFP are write/
                      //erase protected
#FUSES RESERVED       //Used to set the
                      //reserved FUSE bits

#use delay(clock=12000000)
#use rs232(baud=9600,parity=N,
xmit=PIN_C6,rcv=PIN_C7,bits=8)
```

At this point, MPLAB X is not happy. MPLAB X is telling me that it can't find *#include <18F46J13.h>*. Since things aren't quite "done" yet, I'm not going to get too excited about MPLAB X's lack of vision. Let's see what happens if we create a CCS C compiler .c main file.

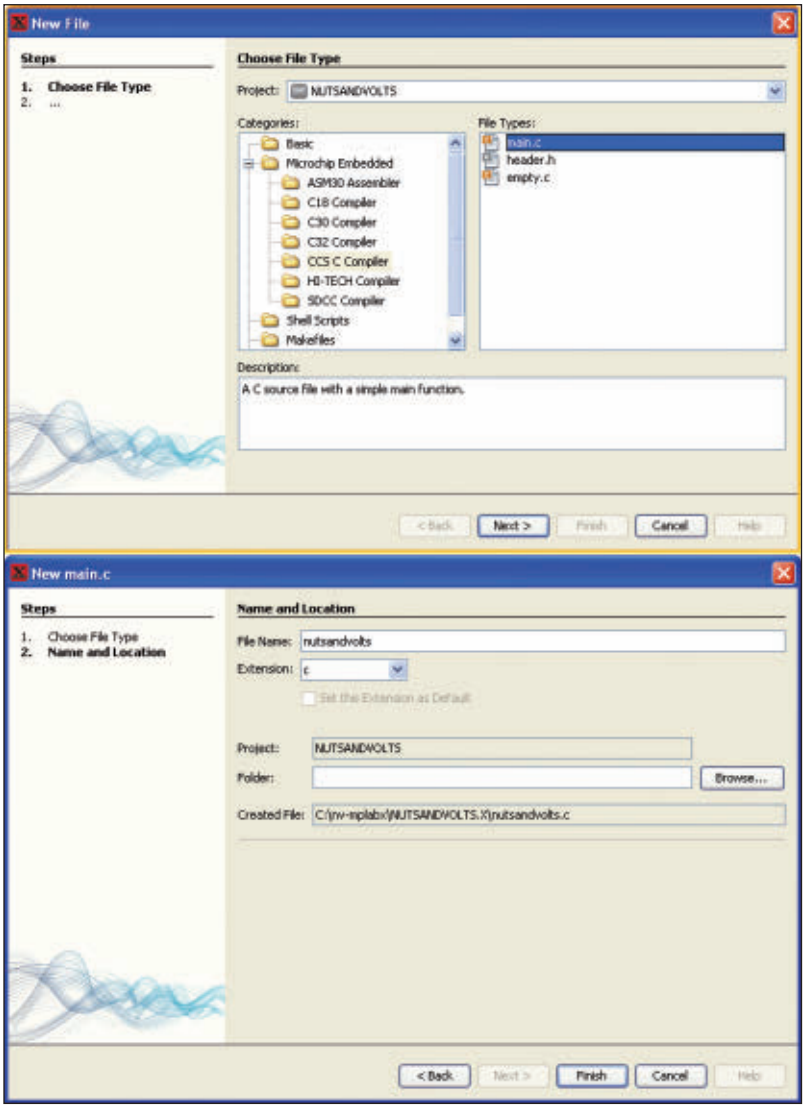
Screenshot 5 is a .c version of **Screenshot 4**. This time around, I chose to go with the MPLAB X's *main.c* template to create the file *nutsandvolts.c*. Here's what MPLAB X gave me:

```
/*
 * File:   nutsandvolts.c
 * Author: Fred
 *
 * Created on November 1, 2011, 3:09 PM
 */

#include <nutsandvolts.h>
void main(void) {
    while (TRUE);
}
```

Now, I've got two problems. MPLAB X can't find *#include <18F46J13.h>* and it can't find the *nutsandvolts.h* file that contains *#include <18F46J13.h>*. Okay. Now, I'm a bit excited. Hopefully, registering the *nutsandvolts.h* and *nutsandvolts.c* files with MPLAB X will solve the problems.

The *nutsandvolts.h* and *nutsandvolts.c* files we created reside in the project directory (*NUTSANDVOLTS.X*). So, I right-clicked on Source Files in the Projects window and chose "Add Existing Item" which resulted in **Screenshot 6**. Since the project is king, MPLAB X automatically looked into the project directory for the existing files. It is also possible to search other folders for files you need to include in the project. Once *nutsandvolts.c* was officially a member of the project, all of the "can't find" errors



■ SCREENSHOT 5. This looks familiar, doesn't it?

disappeared. At this point, I felt that it was okay to flesh out the *nutsandvolts.c* file with the C code that the CCS compiler generated, mixed with my own special sauce:

```
void init(void) {
     setup_psp(PMP_DISABLED);
     setup_spi(SPI_MASTER | SPI_SCK_IDLE_LOW |
     SPI_CLK_DIV_64);
     setup_spi2(SPI_SS_DISABLED);
     setup_wdt(WDT_OFF);
     setup_timer_0(RTCC_OFF);
     setup_timer_1(T1_ENABLE_SOSC);
     setup_timer_2(T2_DISABLED, 0, 1);
     setup_timer_4(T4_DISABLED, 0, 1);
     setup_comparator(NC_NC_NC_NC);


     setup_rtc(RTC_ENABLE);

     setup_low_volt_detect(LVD_TRIGGER_BELOW |
     LVD_30); //3.0 volts

     set_tris_a(0b11111111);

     set_tris_b(0b11101111);
     output_b(0b11011111);

     set_tris_c(0b10010011);
     output_c(0b11111111);

     set_tris_d(0b10011100);
     output_d(0b10011101);

     set_tris_e(0b00000000);
     output_e(0b00001111);

     nutsandvolts_time.tm_year = 11;
     nutsandvolts_time.tm_mon = 9;
     nutsandvolts_time.tm_mday = 29;
     nutsandvolts_time.tm_wday = 6;
     nutsandvolts_time.tm_hour = 14;
     nutsandvolts_time.tm_min = 34;
     nutsandvolts_time.tm_sec = 0;
     rtc_write(&nutsandvolts_time);
     lastsec = nutsandvolts_time.tm_sec;

     enable_interrupts(INT_HLVD); //LOW VOLTAGE
     INTERRUPT
     enable_interrupts(GLOBAL);

}
```

I've prepared the PIC18F46J13 for interrupt on low voltage detect and activation of the PIC's RTCC. The RTCC routines are part of the CCS C PIC18F46J13 device driver. The plan is to have the PIC keep time and rely on battery backup to keep the time when main power drops below 3.0 volts. Let's see if this puppy will compile.

COMPILING AND RUNNING OUR MPLAB X PROJECT

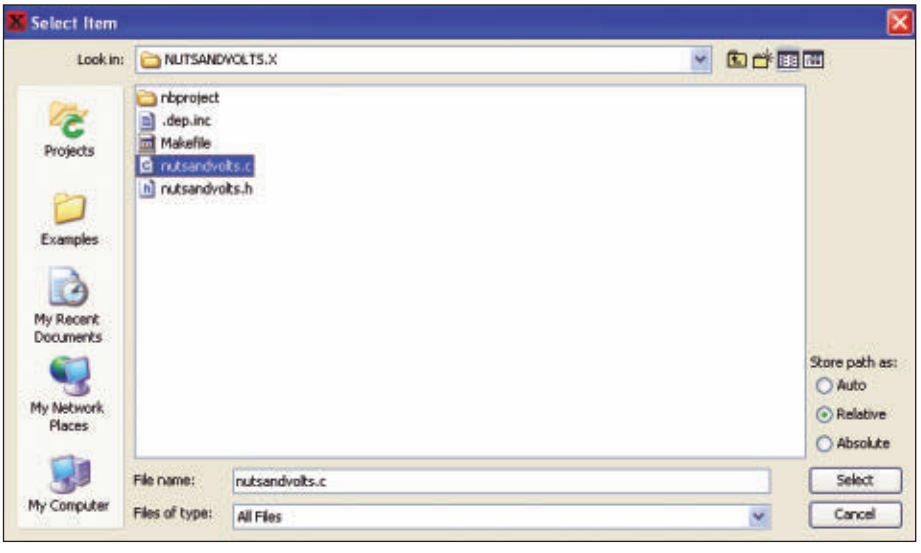
MPLAB X allows the human programmer to build the project; build the project with a clean; build the project into debug; and make and program the project. I kinda like the automated make and program option. If things go as planned, the time beginning at 14:34 will be sent every second via the PIC18F46J13's serial port to an AccessPort terminal emulator session. What do you think about **Screenshot 7**?

BACK TO BASICS

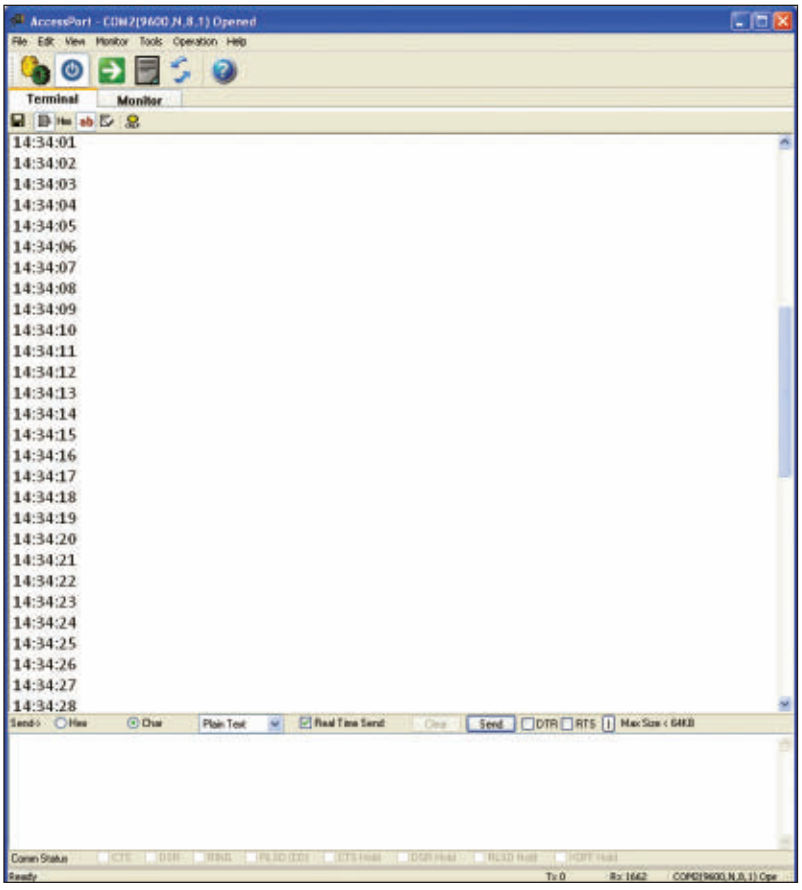
Let's use what we've learned about creating a CCS C project using MPLAB X and apply it to creating an MPLAB X project for the PICBASIC PRO compiler. The project creation steps are identical, except we must replace any references to the CCS compiler with PICBASIC PRO compiler directives.

We begin by creating an MPLAB X embedded standalone project. We'll call our PICBASIC PRO project *PBP3_MPLABX*. Naturally, as you can see in **Screenshot 8**, we'll select the PICBASIC PRO compiler as the project compiler. When the project creation steps are complete, we will have created a project folder called *PBP3_MPLABX.X*.

PBP3_MPLABX.X is lacking a PICBASIC PRO source code file at this point. So, we'll right-click on Source



■ SCREENSHOT 6. Officially adding the nutsandvolts.c file made MPLAB X very happy. The "I can't find 'em" errors ran for the hills. Note that MPLAB X reached into the project directory automatically for the existing items.



■ SCREENSHOT 7. Mission accomplished. We've used MPLAB X and the CCS C compiler to put the PIC18F46J13 to work. Don't worry. I'll provide the CCS C source code in the download package.

Files and add a new file formatted for the PICBASIC PRO compiler. Note that a PICBASIC file selection is offered in **Screenshot 9**. Our new PICBASIC PRO file is called *PBP3CODE.pbp*. Here's what the MPLAB X PICBASIC file template placed in the newly created file:

```
'****************************************
'*  Name    : PBP3CODE
'*  Author  : Fred
'*  Notice  : Copyright (c) 2010
'*          : All Rights Reserved
'*  Date    : Nov 3, 2011
'*  Version : 1.0
'*  Notes   :
'*          :
'****************************************
```

The first order of business is to specify the PIC18F46J13's configuration fuse settings. To make the job easy, reference the *PIC18F46J13.PBPINC* file which is a part of the PICBASIC PRO compiler install package. All of the valid configuration fuse settings are contained within the *PIC18F46J13.PBPINC* file. Here's how we should configure the PIC18F46J13:

```
#CONFIG
    CONFIG WDTEN = OFF      ;Disabled -
                          ;Controlled by SWDTEN bit
    CONFIG PLLDIV = 1       ;No prescale (4 MHz
          ;oscillator input drives PLL directly)
    CONFIG CFGPLLEN = OFF   ;PLL Disabled
    CONFIG STVREN = ON      ;Enabled
    CONFIG XINST = OFF      ;Disabled
    CONFIG CP0 = OFF        ;Program memory
                          ;is not code-protected
    CONFIG OSC = HS         ;HS
    CONFIG SOSCSEL = HIGH   ;High Power T1OSC/
                         ;SOSC circuit selected
    CONFIG CLKOEC = OFF     ;CLKO output
                       ;disabled on the RA6 pin
    CONFIG FCMEN = OFF      ;Disabled
    CONFIG IESO = OFF       ;Disabled
    CONFIG RTCOSC = T1OSCRE ;RTCC uses
                          ;T1OSC/T1CKI
    CONFIG DSBOREN = OFF    ;Disabled
    CONFIG DSWDTEN = OFF    ;Disabled
    CONFIG IOL1WAY = ON     ;The IOLOCK bit
                 ;(PPSCON&lt;0>) can be set once
    CONFIG ADCSEL = BIT10   ;10 - Bit ADC
                          ;Enabled
    CONFIG MSSP7B_EN = MSK7 ;7 Bit address
                          ;masking mode
    CONFIG WPCFG = OFF      ;Configuration Words
                 ;page not erase/write-protected
    CONFIG WPDIS = OFF      ;WPFP[6:0], WPEND,
                        ;and WPCFG bits ignored
#ENDCONFIG
```

Once the configuration fuses are specified, we need to tell the PIC how to spit out the time values to a serial port. Basically, we inform the PICBASIC PRO compiler as to how fast the PIC is being clocked and enable the PIC's hardware UART:

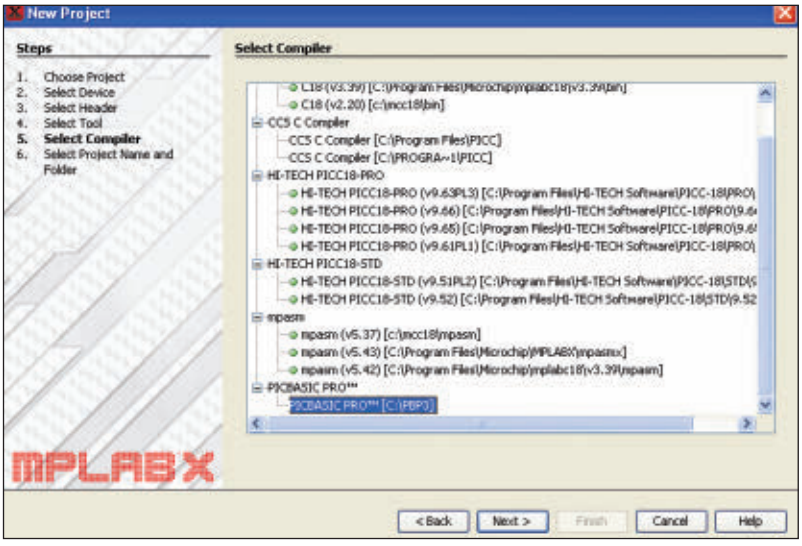
```
    define OSC 12
    define HSER_RCSTA 90h
    define HSER_TXSTA 20h
    define HSER_BAUD 9600
```

Once the compiler knows that we're running our PIC18F46J13 at 12 MHz, it "automagically" calculates the SPBRG values for our specified baud rate of 9600 bps.

A PICBASIC PRO CODE MPLAB X EXAMPLE

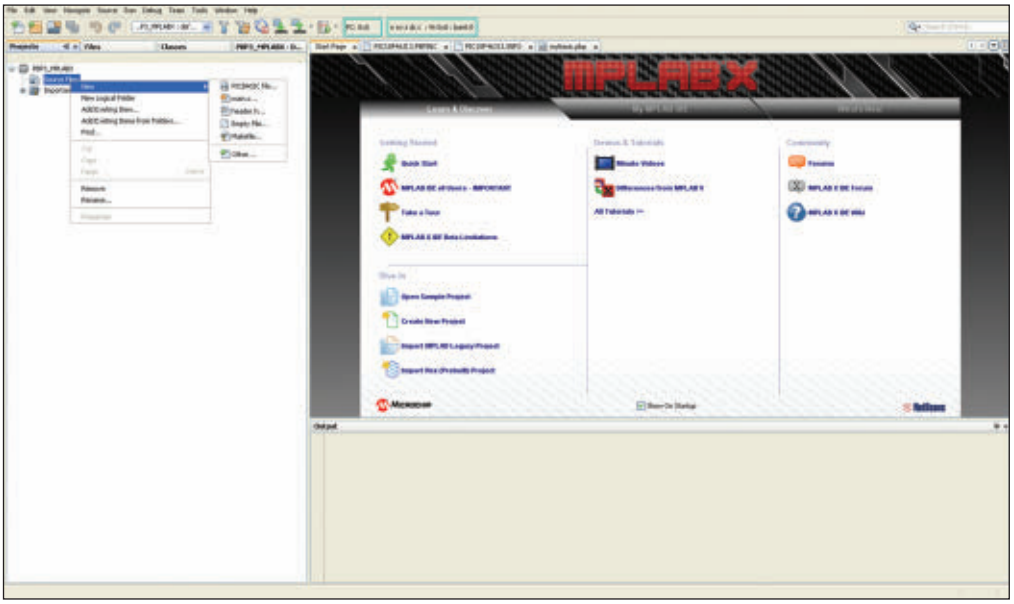
What follows in the PICBASIC PRO code is a driver for the PIC's internal RTCC. The driver consists of subroutines that set and read the RTCC clock registers. You can use the RTCC routines to perform events under the control of the time generated by the RTCC. However, that wouldn't do here because you couldn't see the results of the RTCC's work. So, I funneled the time out of the RTCC into a terminal emulator. Here's the code I've written to set the RTCC registers:

```
SET_TOD:
    EECON2 = $55            ;unlock sequence
    EECON2 = $AA
    RTCCFG.5 = 1            ;write enable RTCC
register
```



■ SCREENSHOT 8. Selecting PICBASIC PRO compiler 3.0 as the project compiler kicks off all of the MPLAB X PICBASIC PRO configuration activity that will put a PICBASIC PRO compiler flavor on all of the project's attributes.

```
      RTCCFG  = %00100011
      RTCVALL = currentyear
      RTCCFG  =  %00100010
      RTCVALL = currentday
      RTCVALH = currentmonth
      RTCVALL = currenthour
      RTCVALH = currentweekday
      RTCVALL = currentsec
      RTCVALH = currentmin
      RTCCFG.7 = 1      ;start the clock
      EECON2  = $55     ;unlock sequence
      EECON2  = $AA
      RTCCFG.5 = 0      ;write disable RTCC
                        ;register
RETURN
```



Note the unlock sequences. They are required to allow and prevent access to the write enable and clock enable bits in the RTCCFG register. Once the RTCC has been loaded with the current time and date values, the clock is started. To be able to use the RTCC, we've got to be able to read its registers on the fly. Yep, I wrote some code to do that:

■ SCREENSHOT 9. Once MPLAB X makes the new PICBASIC PRO file available to us, we'll flesh it out with some PICBASIC PRO source that will drive the PIC18F46J13's RTCC.

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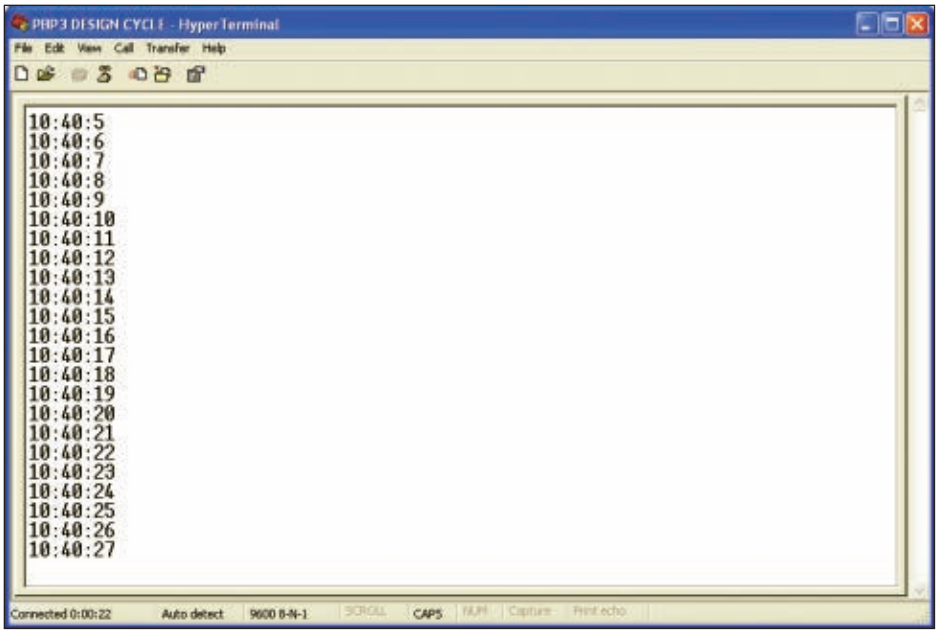
■ SCREENSHOT 10. I once had a very competent programmer tell me "It doesn't matter what programming language you use, as long as you get the desired results."




```
GET_TOD:
     RTCCFG = %10000011
     currentyear = RTCVALL
     RTCCFG = %10000010
     currentday = RTCVALL
     currentmonth = RTCVALH
     currenthour = RTCVALL
     currentweekday = RTCVALH
     currentsec = RTCVALL
     currentmin = RTCVALH
RETURN
```

As you can see, reading is just a reversal of roles between the time/date variables and the RTCC registers.

As you would imagine, the main example algorithm simply reads the clock continuously and checks for a rollover of the seconds register. Every time the seconds register is incremented, the current time is transmitted to the terminal emulator. The results can be seen in **Screenshot 10**.

THE X FACTOR

MPLAB X contains mountains of features we didn't touch on in this discussion. The more you use MPLAB X, the more you will learn about it. MPLAB X allowed me to use a PICkit3 for programming and debugging both the C and BASIC projects we hammered out. As you uncover MPLAB X features, you'll ask yourself why you haven't already added this incredible IDE to your design cycle. **NV**

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>>> QUESTIONS

Autorangeing DVM Using 7101

I want a small circuit using a microcontroller to convert an analog DVM to an autoranging DVM using a 7107 IC. Or, just explain how to convert the input of a 7107 DVM to an autoranging input.

#1121 Gurdeep Singh
Delhi

Power Supply For Fluke 8050A and 8600A

I have a couple of older Fluke 8050A and 8600A multimeters that were outfitted with battery options. The batteries are long gone and I never really used it anyway. I would like to use them as bench only meters and reconfigure them to a non-battery type supply. Does anyone have an internal power supply plan that I could use in these meters without drilling holes in the cases and cutting up traces on the circuit boards? Something using capacitors, diodes, etc., that would fit into the battery area and plug directly into the battery connections.

#1122 David Asselin
Saint-Lambert, Quebec

Multi Output Power Supply

I want to know the simplest solution for this power supply need. My input is 36-75 DC.

I need these outputs:
+-65V @ 70 ma
+5V @ 200 ma
+-15V @ 150 ma

#1123 Ali Asadzadeh
Shiraz, Fars

Self-Powered Current Switch

I would like to know how to build a self-powered currect switch to monitor a lamp pole light. I need it to output an open or closed contact, so I can sense if there is current or not.

The light pole voltage is 120V at a range of 1A-10A. Anything above 200-500 ma current is on or closed contact. Otherwise, no current, open contact. I need it as small as possible and over-voltage and over-current protected.

Any help out there?

#1124 Christopher LeFrois
Lincoln, NE

Yagi Antenna Question

I live where cellular reception is poor, and I depend on a cellular modem, amplifier, and Yagi antenna (Wilson Electronics 301111) mounted on our chimney for an Internet connection. In the summer it works pretty well, but in the rainy winter, the signal deteriorates significantly and our connection speed drops. If we're using the fireplace, and the weather dries out for a few days, the signal improves. However, if it's rainy but we're *not* using our fireplace for a few days, the signal also improves.

My best guess as to the reason is that the combination of smoke from our fireplace and moisture from rain or dew are coating the antenna with a film that is conductive enough to create a partial short across elements of the antenna, causing some attenuation of the signal. The antenna is mounted about six or seven feet above the chimney cap, and it's not really practical to mount it higher without going to a much more complicated mast setup with guy wires.

I'd like to know if I can spray some insulating coating on the Yagi antenna that will prevent the film contacting the conductive parts of the antenna, but that also will not in itself attenuate the signal. Something like WD-40 might work for a while — causing water to just run off — but I want something more permanent, like maybe liquid tape that hardens into a rubbery coating. I just don't know if that type of coating might in itself attenuate the signal.

Does anybody have any advice on how I could seal my antenna without attenuating the signal by an appreciable amount? I'm also open to other ideas, except to go to a different connection technology (DSL isn't available, T1 is too expensive, satellite is worse than what we've got now).

#1125 Gary Rathbun
Placerville, CA

Troubleshooting

How does one replace a spider IC?

#1126 Frank
Enugu, Enugu

Vintage Transformers

I have some industrial equipment inherited from a deceased customer. Two transformers, vintage WWII, 10 and 5 KVa and one transformer probably, 15 KVa with SCRs but no control board. This equipment was originally intended for wire heat treat service, 28 VAC secondaries. I have had them 20 years or more. I've been trying to cook up a stable circuit for firing SCRs for all the transformers. I have worked with such circuits all my professional life but [now 76 yrs] stability is eluding me. Industrial electrical service is always noisy and welding especially so. I know I need zero crossing sync and I need 0.008 sec to zero sec adjustability for the triggers. It must also be jitter free. This is just a hobby

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because nobody buys antique transformers except for scrap, which might be my best business decision considering the times. I do have the transformers and the SCRs. My heirs can scrap the units out after my reward. I have lots of scrapables to play with and nothing else but time.

#1127 Robert Gibson
Aurora, IL

LCD Display Help

In the recent article on the web-based thermostat (Sep-Oct'11) an EA DOG-M LCD display was used. I have two of these displays and haven't been able to get them working. I use PICBASIC PRO and it seems there are a lot of people that are trying to use this LCD with some trouble. There isn't much in the way of information on the forums. Could someone please show how to initialize the display with PICBASIC PRO in both SPI and four-bit mode?

#1128 Craig
Bettendorf, IA

Extra Bright Picture/Exit Bulb

I'm looking for help locating or building a super bright exit/picture/display style bulb with an E26 base for my mom.

My 95 year old mother has macular degeneration in both eyes. She still enjoys reading but finds it harder by the day. Her main complaint is that she can't get enough light on the printed page.

I'm asking for help to locate and/or build a bulb with what I know as ultra-bright LEDs. It will throw the equivalent of 200 [fairly cold] incandescent watts of light down onto her page. I'm no engineer, but am handy with a soldering iron and multimeter. Can anyone help me?

#1129 Rod Reynolds
Bowie, MD

Half Cycle Magnetizer

I'm looking for a half cycle magnetizer schematic for 60 cycle, 120 volts. I used one at work before I retired, but it was built for a higher industrial voltage. I would like to build one from scratch using the standard 120 volt line. I know that it must be contained in a protective box, takes many turns of transformer windings, and uses a high speed thyristor.

#11210 Bob Macias
Fernandina Beach, FL

>>> ANSWERS

[#11115 - November 2011] Power Conversion

I would like to make a special power supply/converter with a difference. It can be supplied from:

- *A nominal 12 VDC (nine to 15 actual) from a vehicle supply.*
- *Or by a nominal 24/28 VDC supply (20 to 32) from a vehicle or aircraft supply.*
- *Or, by international mains (90 to 250 VAC).*
- *All three inputs need to be isolated and capable of being accidentally or deliberately connected at the same time.*
- *Have all three inputs tolerant to transients, e.g., mains derived from generator.*

The unit needs to have four outputs, all of which are DC and each of which is configurable internally by a trim pot to deliver four output voltages between 10 and 24 VDC (e.g., 12V, 15V, 18V, and 22V).

- *Output to be unaffected by change of input source.*
- *Once set, each output voltage needs to maintain a tolerance of ±0.5 VDC, regardless of input changes.*
- *Each output to be capable of delivering 120 watts.*
- *Robust, portable unit.*

I understand that these parameters are often mutually exclusive, but the following considerations are also desirable:

- *Low weight.*
- *Small size.*
- *Low heat dissipation.*
- *Low noise.*
- *Low interference.*
- *High quality.*

If the overall concept is too big, perhaps someone could direct me to previous power conversion solutions that may be married together to give a solution, and highlight the isolation issues that may apply regarding multiple input connections.

My goodness! Four 120-watt outputs? I think you are pretty well stuck with switching power supplies here! I'm not a switching power supply guru — to put it mildly! — so I won't try to design that, but I will suggest an 'architecture.'

Clearly, you need four switching power supplies for the four different output voltages (or at least, that seems the cleanest to me).

I would suggest having three input switching power supplies to convert the three differing input voltages to some handy intermediate voltage that the four output switchers take as their input. Set the output of each switcher such that the mains gives a few volts more than the other two, and then pick which one of the other's you want to supply the power if both are hooked up. Isolate these three input supplies from each other with diodes. That is, each of these three has a diode between it and the intermediate supply rail. With the mains switcher having the higher output voltage, it will take (most of) the load even if the other two are active. The diodes will keep the three input switchers from feeding each other.

Rusty Carruth
Tempe, AZ

[#11119 - November 2011] Loudspeaker/CB Combination

I was wondering if it would be possible to cheaply build a system in which I speak into a CB type radio and

have the signal sent to a loudspeaker about 1,000 feet away or slightly more. The current system I have is a bullhorn, and I have to stand a good distance back from the crowd to accomplish my task. It kills my voice. I was thinking if I could buy a loudspeaker (what wattage?) and a set of CBs that I should be able to modify the other CB to feed into the amplified loudspeaker so I can simply talk into it.

While this is definitely possible, CB wasn't really made for this; the quality may not be good enough but if you don't want to buy an FM mic/receiver or build an FM mic kit to FM radio receiver, then this will work. It will also all work on 12V which may be needed.

First, at your location test out the CB with a good mobile whip antenna and see what it receives. Remember, for receive only it really doesn't need to be properly balanced. The SWR doesn't really matter and, in fact, an antenna with worse reception due to poor SWR may end up being better for this application. DO NOT transmit from the "receiving" radio into a poor antenna. One reason a poor receiving antenna may be better right now is that skip is starting to come in as I write this in November 2011, so you may have to contend with competition. Remember there is NO stronger signal capture for CB AM signals as there is for FM receivers. Also, if you're close to a major highway — unless you can find a clear channel — this may not work at all. Keep in mind that there may be traffic on whatever channel you pick. The receiving radio should have the squelch set to its highest setting to keep out as much other traffic and noise as possible but NOT during your tests. The test should be run with either squelch open or at the lowest setting possible for white noise only block-out.

You might need to build a poor receiving antenna to restrict what the receiver picks up. If you need suggestions on that, check out **http://cs.yrex.com/ke3fl** (my website). I wrote an article for building CB HT "rubber duck" type antennas. The article was published in *Popular Communications* a few years ago. You will probably want to limit your output power to as low as needed for the distance you're covering, which I'm assuming is line of sight. A 100 mW transmitter may be enough for 1000'. Recommendation: Either find or modify the handie-talkie. You want one that runs on AA cells — not AAA or 9V batteries since the AAs are far more cost-effective and have a much better energy density. They will last longer — MUCH longer — than a single 9V battery and more than 3X longer than AAA batteries. The higher the voltage the better, so an HT using 12V is better than one using 9V, which is better than one using 6V as far as current draw for the same power output. This means the 12V will last longer than the 9V (which will last longer than the 6V assuming they all use the same kind of batteries).

If the CB receiver you are using doesn't have enough audio power to drive the external speaker you want, then you'll need to put together — pick up at a yard sale or hamfest or buy and build — a small audio amplifier to take the output from the SPK (external speaker) jack of the CB radio to the input of the amplifier that then drives the speaker.

I have seen kits from RAMSEY Electronics, Inc. (**www.ramseykits.com**) for audio amplifiers (you only need a mono-amp, not stereo), as well as small FM broadcast transmitters. I'm sure there are others as well (Jaycar, **www.jaycar.com** and Cana Kit Corp. **www.canakit.com** — both of which may have audio amps and FM transmitters). Unless you have a very well stocked junk drawer, I'd buy a kit. At Ramsey, there is a 10W audio amp, (#CK003, doesn't say stereo) for ~$13. If you're using a CB receiver, you do NOT need a mic pre-amp. Cana Kits has the same audio amp for the same price as Ramsey, but they also have some stereo amps at 25W and 35W per channel, ~$44 and $70, respectively. I was unable to check **jaycar.com**.

Phil Karras, KE3FL

continued from page 27

computer VGA cable.

The transceiver's microphone, control, and speaker jacks are connected to corresponding jacks in the co-located SMR which translates the radio's conductors to those of a VGA cable. At the remote location, an identical SMR maps the VGA conductors back to the transceiver's connections. The microphone, control, and speaker plug into the SMR's jacks as if they were connected directly to the radio. By changing the SMR's jumpers, different radios can be used in the same car, or one transceiver can be used in different cars by running VGA cables in both of them. Replacement radios are installed simply by changing SMR jumper settings.

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DUAL MOTOR DRIVER SHIELD FOR ARDUINO

Pololu announces the release of the dual VNH5019 motor driver shield for Arduino which provides an easy way to control up to two high power DC motors with an Arduino

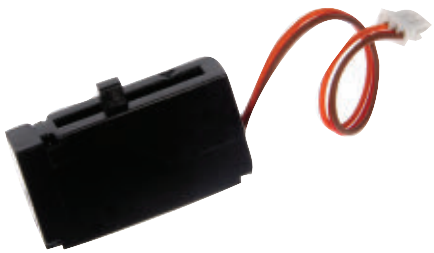
or Arduino-compatible device. The shield's twin robust VNH5019 motor drivers operate over a wide 5.5V to 24V range and can each deliver a continuous 12A (30A peak) to an independently controlled motor. Or, the driver outputs can be combined to deliver a continuous 24A (60A peak) to a single motor. The motor drivers also offer current-sense feedback and accept ultrasonic PWM frequencies for quiet operation.

This motor driver is intended for a wide range of users, from beginners who just want a plug-and-play motor control solution for their Arduinos (and don't mind a little soldering) to experts who want to directly interface with ST's great motor driver ICs. The Arduino pin mappings can all be customized if the defaults are not convenient, and the VNH5019 control lines are broken out along the left side of the board for general-purpose use without an Arduino. This versatility – along with an option to power the Arduino directly from the shield – sets this board apart. The shield (item #2502) is available for $59.95.

For more information, contact:
Pololu Corporation
Web: **www.pololu.com**

NEW PICO LINEAR SERVO

Now available from Solarbotics is the VS-19 pico linear servo which is a tiny and affordable linear actuator with 2 cm of travel. A linear actuator is an actuator that creates linear motion, as opposed to rotary motion, i.e., the spinning of a motor. Many linear actuators (such as this one), are actually driven by a non-linear motion. The VS-19 uses a geared pager motor to spin a worm gear section with a floating nub.



The VS-19 can be used to turn light switches on and off, raise and lower legs, trigger a latch, and/or bring up a periscope. Because of its size, it's perfect for stealthy remote control applications. This actuator accepts a servo pulse from 800-2,200 microseconds (uS) with a neutral position of 1,500 uS.

The traveling nub takes about a second to move from one side of the channel to the other (2 cm) at 3.7V. This linear servo can run at voltages as low as 2.5V, but at the expense of speed. Price is $9.85.

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Programmable DC Electronic Load 0~80V / 0~40A

The 3721A Programmable DC Electronic Load provides excellent performance with sophisticated features found on much more expensive units. This 400 watt, 40 Amp, 0~80 volt Programmable DC Electric Load can be used to test all sorts of DC power sources including power supplies and is especially helpful to battery manufacturing processes. This DC load features constant voltage, constant resistance, constant current and constant power settings. The end user can design programs that control precisely all of the load values and time durations for each step of a test sequence. Up to nine 10 step programs can be internally stored in the 3721A Programmable DC Load.

- **4 basic functions: CC, CV, CR & CP**
- **8 basic test modes: CCL, CCH, CV, CRL, CRM, CRH, CPV & CPC**
- **Minimum operating voltage is less than 0.6v at the load's full rated current.**
- **High-speed sequence, high-speed transient, short circuit, battery discharge and other functions.**
- **Programable current slew rate.**
- **Multiple groups of parameters and lists can be saved & recalled.**
- **Supports SCPI and LabView with included software.**

Current Rating: 0~40A

Voltage Rating: 0~80V

Power Rating: 400W at 40°C

Item#
CSI3721A **$720.00**

www.CircuitSpecialists.com/CSI3721A

Programmable DC Electronic Loads

These devices can be used with supplies up to 360VDC and 30A. It features a rotary selection switch and a numeric keypad used to input the maximum voltage, current and power settings. These electronic DC loads are perfect for use in laboratory environments and schools, or for testing DC power supplies or high-capacity batteries. It also features memory, and can also be connected to a PC, to implement remote control and supervision.

360V/150W (CSI3710A) $349.00
www.circuitspecialists.com/csi3710a

360V/300W (CSI3711A) $499.00
www.circuitspecialists.com/csi3711a

Your *Hot Air Rework* Headquarters

Surface-Mount components have taken over from through-hole components in many electronic products produced today. Circuit Specialists, Inc stocks numerous Hot Air Rework solutions to handle this trend.

Our many rework solutions offer a wide range of nozzle designs and many have built-in holders for efficient placement of the air stream for proper application of heat/airflow over the desired component.

www.circuitspecialists.com/hot-air-rework

BlackJack SolderWerks Hot Air System with Suction Pen & Mechanical Arm.
BK4050 $119.00
www.circuitspecialists.com/bk4050

CircuitSpecialists.com ESD Safe, CPU Controlled, SMD Hot Air Rework Station with Hot Air Gun & Suction.
CSI825A $99.00
www.circuitspecialists.com/csi825a

BlackJack SolderWerks Hot Air Rework Station with Digital Display, Mechanical Arm & 70w Soldering Iron.
BK5050 $169.00
www.circuitspecialists.com/bk5050

CircuitSpecialists.com ESD Safe SMD Rework Station with Hot Air Gun & Soldering Iron.
CSI906 $99.00
www.circuitspecialists.com/csi906

BlackJack SolderWerks Deluxe Rework System with Hot Air, Soldering Iron, Suction Gun & Mechanical Arm.
BK6000 $229.00
www.circuitspecialists.com/bk6000

CircuitSpecialists.com Hot Air Gun w/Digital Display for Surface Mount Devices.
CSIHOTGUN-2 $89.00
www.circuitspecialists.com/csihotgun-2

CircuitSpecialists.com Compact Rework Center with Hot Air Gun and Soldering Iron.
CSI899A+ $99.00
www.circuitspecialists.com/csi899a+

CircuitSpecialists carries a large selection of Nozzles for BGC, PLCC, QFP, SOP and single point applications.
www.circuitspecialists.com/hot-air-nozzles

60 Watt Digital Soldering Station

For use with traditional or Lead Free Soldering

This is a terrific soldering station featuring a microprocessor controlled temperature set up system with great versatility. The unit includes 3 preset temperature settings that are user definable so you can turn on the system & push one button to go to the temperature range you desire. Specific system temps can also be set with an easy to use push button up/down button AND when you turn off this station, the unit keeps the last used temperature in memory & automaticly returns to that setting the next time the user turns the system on. The temperature display can be set to display in Celsius or Fahrenheit scale.

The CSI-Station-3DLF is a powerful 60 watt soldering system. The fast heat recovery provided by a 60 watt system like this allows the user to solder both traditional solder and lead free solder. This system features a grounded tip to protect delicate circuits from static charge. Also included is a seperate iron holder. Circuit Specialists stocks a large supply of tips for this station.

Features:

* 60 watt dual core ceramic heater
* 150 to 450 degree Celsius Temperature range
* Versatile easy to read liquid crystal display
* 3 preset & user definable temperature settings.
* Automaticly remembers previous temperature setting
* Display in Celsius or Fahrenheit scale
* 3 foot cord length from station to iron tip
* Broad selection of replacement tips available

Item#
CSI-Station-3DLF **$49.00**

www.CircuitSpecialists.com/CSI-Station-3DLF

Circuit Specialists carries a wide selection of traditional & lead-free soldering equipment, including soldering irons, soldering stations, hot-air rework stations, focused infrared systems, reflow ovens, pre-heating systems, regular and lead-free solder, solder flux, and soldering aids for both thru-hole and surface-mount soldering.

See our complete line of soldering equipment at:

www.CircuitSpecialists.com/soldering-equipment

We carry a LARGE selection of Power Supplies, Soldering Equipment, Test Equipment, Oscilloscopes, Digital Multimeters, Electronic Components, Metal and Plastic Project Boxes, Electronic Chemicals, PC Based Digital I/O Cards, Panel Meters, Breadboards, Device Programmers, and many other interesting items. Check out our website at: *www.CircuitSpecialists.com*

Best Value, Low Cost Station

CSI-Station1A

Easily our best value in our selection of soldering stations. O.E.M. manufactured just for Circuit Specialists Inc., so we can offer the best price possible! The CSI-Station1A features a grounded tip & barrel for soldering static-sensitive devices and uses a ceramic heating element for fast heat up & stable temperature control.

The control knob is calibrated in Fahrenheit & Celsius (392° to 896°F and 200° to 480°C). One of the nicest features is the high quality comfort grip soldering iron. The iron connects to the station via an easy screw-on connector making iron replacement a snap. The 1 meter length iron cord provides plenty of length for users to set up the station in a convenient location. Another nice feature is the soldering iron holder. Made of rugged aluminum,it is a seperate piece from the main station & allows the user maximum convenience.....you don't have to reach all the way back to the station to store the iron. Yet another feature is the stackable design of the CSI-Station1. The main station is designed for an additional unit to be placed on top of it allowing for space saving placement of the CSI-Station1A. Also included at no additional charge is one user replaceable ceramic heating element so that you will be prepared! Large selection of soldering tips available too.

Item#
CSI-STATION1A **$29.95**

www.circuitspecialists.com/csi-station1a

3 Channel Programmable Regulated DC Power Supplies

Check out our new programmable hi preformance 3 channel power supplies. Featuring both USB & RS232 interfaces, Overload Protection, Auto Fan Control, and Series or Parallel Operation. Both units feature a Large LCD display panel with simultaneous output and parameter view and a keypad for control. They are ideal for applications requiring high resolution, multiple output, and automated operation such as in production testing. There are both fine and coarse controls via the shuttle knob and 90 memory settings. Software included.

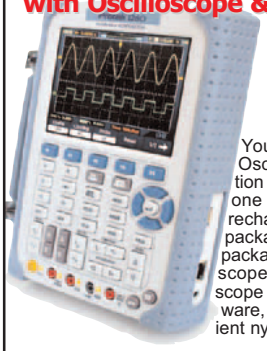
CSIPPS33T 0~32V / 0~3A **$299.00**

www.CircuitSpecialists.com/CSIPPS33T

CSIPPS55T 0~32V / 0~5A **$379.00**

www.CircuitSpecialists.com/CSIPPS55T

200MHz Hand Held Scopemeter with Oscilloscope & DMM Functions



Includes 1 Year USA Warranty

You get both a 200 MHz Oscilloscope and a multi function digital multimeter, all in one convenient lightweight rechargeable battery powered package. This power packed package comes complete with scopemeter, test leeds, two scope probes, charger, PC software, USB cable and a convenient nylon carrying case.

- 200MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 200MHz Bandwidth with 2 Channels
- 500MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # DSO1200 *New Low Price!* **$589.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter with Oscilloscope & DMM Functions

- 60MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 60MHz Bandwidth with 2 Channels
- 150MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # DSO1060 *New Low Price!* **$429.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter w/Oscilloscope, DMM Functions & 25 MHz Arbitrary Waveform Generator

- All the features of the DSO1060 plus a 25 MHz Arbitrary Waveform Generator.
- Waveforms can be saved in the following formats: jpg/bmp graphic file, MS excel/word file
- Can record and save 1000 waveforms
- DC to 25 MHz Arbitrary Waveform Generator

Item # DSO-8060 *New Low Price!* **$519.00**

www.circuitspecialists.com/DSO-8060

Programmable DC Power Supplies

- Up to 10 settings stored in memory
- Optional RS-232, USB, RS-485 adapters
- May be used in series or parallel modes with additional supplies.
- Low output ripple & noise
- LCD display with backlight
- High resolution at 1mV

Model	CSI3644A	CSI3645A	CSI3646A
DC Voltage	0-18V	0-36V	0-72V
DC Current	5A	3A	1.5A
Power (max)	90W	108W	108W
Price	**$199.00**	**$199.00**	**$199.00**

Hantek 5000B Series Digital Storage Oscilloscopes

Introducing the Hantek 5000B Series Digital Storage Oscilloscopes. Available in 60MHz, 100MHz and 200MHz Bandwidths. Each one provides real-time sample rates up to 1GSa/s and equivalent sample rates up to 25GSa/s. In addition, they have a maximum 1M memory depth for better observation of waveform details. The 7 inch color TFT LCD Display with Windows-style interface and menus provide easy operation.

Abundant menu information and easy-to-use buttons give you plenty of measurement information:

The multifunctional knobs and the powerful shortcut keys help save time during operation.

The Autoset function lets you detect sine and square waves automatically.

The Probe Check Wizard guides you to adjust the probecompensation and set the Probe option attenuation factor.

Three help methods (context-sensitive, hyperlinks, and an index).

You can quickly master all functions to greatly improve your efficiency in production and development.

Features:
- 60, 100 or 200 MHz bandwidth
- 1GSa/s Real Time sample rate
- 25GSa/s Equivalent sample rate
- Large (7.0-inch) color display,WVGA(800x480)
- Record length up to 1M
- Trigger modes: edge/pulse width/line selectable video/slop/overtime etc.
- USB host and device connectivity, standard
- Multiple automatic measurements
- Four math functions, including FFTs standard
- Provides software for PC real-time analysis

3 Models to choose from

DSO5062B
60MHz Digital Storage Oscilloscope
$385.00

www.circuitspecialists.com/dso5062b.html

DSO5102B
100MHz Digital Storage Oscilloscope
$499.00

www.circuitspecialists.com/dso5102b.html

DSO5202B
200MHz Digital Storage Oscilloscope
$599.00

www.circuitspecialists.com/dso5202b.html

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